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GM/RC2641
Recommendations for Vehicle Static Testing
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Documents

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Recommendations for Vehicle Static Testing

Issue Record

Issue	Date	Comments
One	June 2007	Original document
Two	June 2009	Replaces issue one. Small scale change inserted new clauses RC011a, RC011b, RC086a and revised RC086 and RC087.

Superseded documents

The following Railway Group documents are superseded, either in whole or in part as indicated:

Superseded documents	Sections superseded	Date when sections are superseded
GM/RC2641, issue one Recommendations for Vehicle Static Testing	All	01 August 2009

Supply

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Recommendations for Vehicle Static Testing

Part 1 Introduction

1.1 Purpose and structure of this document

- 1.1.1 This document has been published by Rail Safety and Standards Board (RSSB) to give details of recommended methods which, if followed, would meet the requirements of GM/RT2141 Resistance of Railway Vehicles to Derailment and Roll-Over in respect of static testing. It also contains recommendations for the purpose of vehicle simulation model validation.
- 1.1.2 Should a Railway Group member choose not to follow the recommended method of meeting the requirements of GM/RT2141, which are reproduced in this document, it should assure itself that the method it is following is as effective, and no less safe, than the method that is recommended here.
- 1.1.3 Relevant requirements in GM/RT2141 are reproduced in the sections that follow. Recommendations are provided as a series of sequentially numbered clauses prefixed 'RC'.
- 1.1.4 Specific responsibilities and compliance requirements are laid down in the Railway Group Standard itself.
- 1.1.5 This document contains recommendations that are amended under the Railway Group Standards Code (Issue Three) as a small scale change. Reference to the amended recommendations is made in the 'Issue Record'. All other parts of the document are unchanged from the previous issue.

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1.3 Approval and authorisation of this document

The content of this document was approved by:

Rolling Stock Standards Committee on 27 February 2009.

This document was authorised by RSSB on 8 April 2009.

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Part 2 Recommendations for vehicle static testing

2.1 Background

- RC001 A review of GM/RT2141 highlighted the need for improved definitions of the physical tests carried out on new vehicle types. This is because certain tests were undefined in Railway Group Standards, while others were defined in a way that differs from the methods used in practice.
- RC002 Although most GB rail vehicle test laboratories use similar methods (for historical reasons) this is not necessarily the case for all suppliers, especially companies new to the GB market. Clarifying the test conditions and requirements enables common methods to be used for the acceptance of all vehicles. It also provides consistent baseline data for the validation of models used in simulations for acceptance purposes.
- RC003 The appendices in GM/RT2141 set out the details of a series of tests that may be carried out to satisfy and support its requirements. The recommendations in this document, GM/RC2641, set out a methodology for undertaking those tests.
- RC004 The tests are also appropriate when delivering key elements of GM/RT2149 and GE/RT8006.
- RC005 This document provides recommendations for four generic static vehicle tests as listed below:
- a) Weighbridge test, to determine nominal axle load as required for example in GE/RT8006
 - b) Wheel unloading test, required by Appendix A of GM/RT2141
 - c) Bogie rotational resistance test, required by Appendix B of GM/RT2141
 - d) Sway test, to determine maximum static displacements as required for example in GM/RT2149.
- RC006 A method is laid out for each test, based on existing test procedures. The wheel unloading and bogie rotational resistance test procedures are based on the requirements in Appendices A and B of GM/RT2141, while the weighbridge and sway test procedures are based on the European standard EN 14363.
- RC007 The recommendations have been drawn from a variety of sources, including current and historical standards, and test procedures used by the major GB rail vehicle test laboratories.
- RC008 The minor changes that have been made to the test procedures and included with the methods set out in this document will be incorporated in GM/RT2141 when it is reissued.

2.2 Conditions common to all tests

2.2.1 General

- RC009 Test laboratories should have a standard test procedure for each of the four static tests set out in RC005. The test procedure should describe the operation of the test equipment, and the processing and presentation of results.
- RC010 The test conditions and results should be issued in a formal document and this should set out and justify in detail any alterations made to the standard test procedure. The vehicle number, orientation, modification state, suspension condition and load condition should also be recorded.
- RC011 Where possible, all tests should be carried out on the same vehicle to ensure a consistent set of data.

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- RC011a The range of vehicle conditions to be tested should be determined. Consideration should be given to the effects of:
- a) Vehicle design asymmetry
 - b) Loading, load distribution etc
 - c) Inter-vehicle connections
 - d) Degraded suspension modes or component failure
 - e) Any novel design features.
- RC011b The specified tests and the associated limit values include a margin for the normal variation of vehicle parameters and it is not required to test all conceivable conditions. However special consideration should be given to any features of the vehicle, or its load, which may lead to variations outside the 'historic norm' for similar vehicles.
- RC012 Vehicles with significant friction or hysteresis in the suspension can give inconsistent results caused by locked-in movement, especially after a vehicle has been stationary for several days or weeks as may be the case prior to a test. These effects can be reduced by running the vehicle repeatedly over a section of track with level differences that activate these aspects of the suspension system. It may be necessary to repeat this exercise when vehicles are moved or stored between tests.
- RC013 Vehicles should generally be tested in their new condition. However, effects such as bedding-in, ageing, wear and degradation can cause significant changes to a vehicle's behaviour during its lifetime. Consideration should therefore be given to any effects, which can worsen the performance and lead to an unsafe condition during the life of the vehicle. Where appropriate, recommendation for future testing of and / or restrictions for the vehicle should be included in the test report.
- RC014 The suspension springs of a vehicle, particularly those fitted with rubber springs, are generally matched to within a few percent of one another to avoid large discrepancies in stiffness across a wheelset or pair of wheelsets. If the stiffness of the springs is towards the upper or lower limits of their allowable tolerances, which for rubber springs may be significant, since their stiffness can vary by $\pm 20\%$ of their nominal value, this could have a significant influence on the test results. It is therefore important to know the stiffness of the springs of the tested vehicle's suspension in relation to the nominal design values. Consideration should be given to any effects this might have on the results and be duly noted.

2.2.2 Additional procedures for the purpose of validating a vehicle simulation model

- RC015 Where the test results are to be used to validate a vehicle simulation model the matching error and matching accuracy should be in accordance with paragraphs RC016 and RC017.
- RC016 Matching errors should be calculated as set out in this document. They are always positive, such that they do not cancel each other out when calculating an average error:
- a) Sway test validation:

$$\text{absolute matching error} = |\text{simulation} - \text{measured}|$$
 - b) Weighbridge, wheel unloading and bogie rotational resistance test's validation:

$$\text{percentage matching error} = 100 \times \frac{|\text{simulation} - \text{measured}|}{0.5 \times (\text{simulation} + \text{measured})}$$
- RC017 Matching accuracy limits are set out in this document for each test for both maximum and average matching errors:

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- a) The 'average error' limit controls the overall accuracy of the matching within tight limits.
 - b) The 'maximum error' limit allows for individual spurious results but limits the magnitude of such errors.
- RC018 Where there is any doubt about the matching accuracy of the test results or conditions, the model should be revised and the matching accuracies recalculated.

2.3 Weighbridge test

2.3.1 Scope

- RC019 This section gives recommendations on achieving accurate and repeatable results from the weighbridge test.
- RC020 The purpose of the weighbridge test is to evaluate the vehicle's weight and the distribution of the static vertical wheel forces (wheel loads).
- RC021 The test results are also necessary to validate a vehicle model, for use in a simulation.
- RC022 This includes tests for each of the following parameters:
- a) Total vertical vehicle load
 - b) Vertical load per axle
 - c) Vertical load per wheel.

2.3.2 Vehicle conditions

- RC023 The test vehicle should be tested with the usual operating equipment and fluids installed. This might for example be with the tanks full. However, there are many variations and the most relevant condition may vary with vehicle type. It is important that the implication of variation in operating equipment and fluids is considered (for example the effect of emptying a fuel or water tank) and the most relevant 'worst' case for the test is identified.
- RC024 With respect to vehicles carrying loads or passengers, the test vehicle should be weighed in the tare and the fully laden state. The simulated load status should correspond to the planned maximum permissible occupancy (typically the crush laden weight) or freight load. Where the effects of the maximum permissible occupancy or freight load, on the individual wheel loads, are understood and documented from previous test results, it may only be necessary to test the vehicle in its tare state.
- RC025 The test(s) should be carried out with the suspension in its normal operating condition(s) and in any foreseeable active system failure condition(s) which could affect the vertical wheel load distribution.

2.3.3 Test rig

- RC026 The test rig and the adjacent track should be plain and nominally straight and level. During the test the vertical misalignment measured at each wheelset location should be within the limits $0 \text{ mm} \pm 2 \text{ mm}$. This is necessary to minimise the effects of cross-level and twist. Ideally the test track should be on foundations that minimise rail deflection.
- RC027 It is preferable that the vertical wheel forces under all wheels of the vehicle or one bogie should be measured at the same time. However, equipment that is capable of measuring the vertical wheel forces of one wheelset at a time could be used, with each wheelset being positioned sequentially on the test rig.
- RC028 The test arrangement should be capable of determining the vertical wheel forces to within a suitable tolerance, for example $\pm 20 \text{ kg}$ per wheel load. The rig should be regularly calibrated and tested for accuracy and repeatability.

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2.3.4 Test conditions

- RC029 Tests may be preceded by adjustment of the suspension where this forms part of the normal manufacturing or maintenance procedures. Any adjustment should only be in accordance with the specified vehicle maintenance instructions, unless justification can be made for permitting other means of adjustment. Any adjustment prior to the tests should in principle be carried out by means that do not require the measurement of forces but only require checks of a dimensional character.
- RC030 The influence of friction should be minimised by using the following procedure:
- The vehicle should be run at reduced speed on to the test rig after it has been run over a section of track with level differences that activate the suspension system.
 - After passing over this section of track and during weighing, no alteration or adjustment should be made to the vehicle.
- RC031 At the moment of measurement the vehicle should be free from external forces, such as:
- Brakes should be released
 - Wheelsets should not be externally restrained
 - Non-permanent inter-vehicle connections should be disconnected.
- RC032 Four successive and complete weighing operations should be carried out with the vehicle being run onto the rig for each test and twice from each direction. This can be achieved by turning the vehicle between weighing operations, or by approaching the weighbridge from the opposite direction. The method used should be recorded.

2.3.5 Measured values and evaluation

- RC033 The vertical wheel forces (Q) of all wheels should be measured for each of the four weighing operations. The evaluation should be done using the calculated average of the four values measured for each wheel during the four weighing operations.

2.3.6 Assessment of test accuracy

- RC034 The following values should then be calculated from the average calculated wheel loads from each set of measured values:
- Wheel loads – the vertical load in kN on each individual wheel
 - Wheelset loads – the vertical load in kN on each wheelset
 - Side loads – the total load in kN on each rail (that is all left-hand side and all right-hand side wheel loads)
 - End loads – the total load in kN on each bogie or on each axle (for two-axle vehicles)
 - Total load – the total load in kN of all bogies or all wheelsets of a vehicle.
- RC035 The values for c), d) and e) in RC034 should remain nominally constant regardless of frictional effects or twist. Hence, variation in these values gives an indication of the accuracy of the measurements. The accuracy should therefore be checked and any significant inconsistencies should be investigated and reported.
- RC036 The variation of individual wheel loads gives an indication of the hysteresis in the suspension. If the wheel load results from the four tests are highly inconsistent, an alternative weighing method should be considered such as that described in RC037 and RC038.