PAS 301:2017

Civilian armoured vehicles – Automotive test methods

CPNI
Centre for the Protection of National Infrastructure

VEHICLE SECURITY ADVISORY GROUP
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ISBN 978 0 580 914874

ICS 03.220.99; 43.160

Publication history

First published April 2017

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Foreword

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Acknowledgement is given to the technical author from the Metropolitan Police Service, Special Projects and to the following organizations that were involved in the development of this PAS as members of the steering group:

- Centre for the Protection of National Infrastructure (CPNI)
- The Council for Scientific and Industrial Research (CSIR)
- HORIBA MIRA Ltd
- Jankel Armouring Limited
- MacNeillie & Son Limited
- Metropolitan Police – Fleet Services
- Millbrook Proving Ground Ltd
- OVIK Crossway
- Penman Engineering Ltd
- QinetiQ Group plc
- RunFlat International Ltd
- TRL

Acknowledgement is also given to the members of a wider review panel who were consulted in the development of this PAS.

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The PAS process enables a test method to be rapidly developed in order to fulfil an immediate need in industry. A PAS can be considered for further development as a British Standard, or constitute part of the UK input into the development of a European or International Standard.

Relationship with other publications

The test methods described in this PAS were developed from the *VSAG 12 Part 3 (Draft): Civilian armoured vehicles – Automotive testing handbook* [1] with kind permission from the Vehicle Security Advisory Group (VSAG).

Product testing. Users of this PAS are advised to consider the desirability of third-party testing of product conformity with this PAS. Users seeking assistance in identifying appropriate conformity assessment bodies or schemes may ask BSI to forward their enquiries to the relevant association.

Use of this document

> The PAS refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

It has been assumed in the preparation of this PAS that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions of this PAS are presented in roman (i.e. upright) type. Its methods are expressed as a set of instructions, a description, or in sentences in which the principal auxiliary verb is "shall".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Where words have alternative spellings, the preferred spelling of the Shorter Oxford English Dictionary is used (e.g. "organization" rather than "organisation").

Requirements in this PAS are drafted in accordance with *Rules for the structure and drafting of UK standards*, subclause **J.1.1**, which states, "Requirements should be expressed using wording such as: 'When tested as described in Annex A, the product shall ...'". This means that only those products that are capable of passing the specified test will be deemed to conform to this PAS.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a PAS cannot confer immunity from legal obligations.

Introduction

PAS 301 describes test methods that may be completed on a civilian armoured vehicle (CAV) to assess its automotive characteristics for payload, acceleration, maximum speed, through gear acceleration, handling, braking and run flat. The test methods are set out in a manner to allow each test to be completed independently. If more than one test is required on a CAV then the test order followed is usually payload, acceleration, maximum speed, through gear acceleration, handling, braking and run flat. One or multiple test vehicles may be used to complete testing in accordance with the test methods. Where it is agreed a change in test vehicle specification does not affect the properties being tested then read across of the test results is permitted.

For each test, careful consideration is given to any damage sustained on the test vehicle. If there is a risk of compromising or invalidating any further testing then actions are taken to minimize this risk. For example, new wheels and tyres may be used for the run flat test.

During any phase of testing it might become evident that the CAV design does not achieve acceptable results in accordance with the defined criteria set out in this PAS. In this situation the party requesting testing may be given the option to submit a redesign for retest. If this option is not taken, the test vehicle receives the assessed categorization. The party requesting testing may withdraw at any time from further testing.

The tests may be completed with the minimum requirements set out in this document. However, the party conducting the tests seeks to establish the maximum performance of the CAV.

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1 Scope

PAS 301 describes automotive test methods and performance categories for the payload, acceleration, maximum speed, through gear acceleration, handling, braking and run flat capabilities of a civilian armoured vehicle (CAV).

This PAS does not replace any statutory requirements for the inspection and testing of a vehicle.

NOTE *For example the* European Community Whole Vehicle Type Approval (EC-WVTA) *[2] and* Individual Vehicle Approval (IVA) *[3].*

2 Normative references

The following documents, in whole or in part, are normatively referenced in 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.

BS ISO 3888-1:1999, *Passenger cars – Test track for a severe lane-change manoeuvre – Part 1: Double-lane change*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this PAS, the following terms and definitions apply.

3.1.1 circle of error probability (CEP)

used in a global positioning system (GPS) to define a circle of stated radius where 95% position probability exists

3.1.2 company

manufacturer or converter of the civilian armoured vehicle who has requested testing

3.1.3 gross vehicle mass (GVM)

maximum operating mass of a civilian armoured vehicle as specified by the company, including, the chassis, body, armour, engine, engine fluids, fuel, accessories, operational equipment, driver, occupants and luggage

3.1.4 maximum axle mass

maximum allowable mass specified for each axle

3.1.5 maximum speed

either tyre maximum speed rating of all fitted tyres, maximum attainable speed

3.1.6 operational kerb mass

mass of the complete civilian armoured vehicle, with all operational equipment installed, full tank of fuel, all service fluids and no driver, occupants or luggage

NOTE *Operational equipment might include permanently installed equipment, such as radio equipment and run flat systems.*

3.1.7 operational mass

mass measured at each wheel station when the civilian armoured vehicle is loaded with operational payload

3.1.8 operational payload

gross vehicle mass minus the operational kerb mass

NOTE *For example, operational payload available for driver, occupants, luggage, weapons, and extra fuel cans.*

3.1.9 test site

location where a test is conducted

3.1.10 test vehicle

civilian armoured vehicle that is identical to the final design specification

NOTE *A record may be made of items included in the test vehicle.*

3.1.11 through gear acceleration

civilian armoured vehicle's ability to accelerate through different moving speed ranges with or without gear changes

3.1.12 track surface condition

3.1.12.1 dry

surface is not affected by water, slush, snow or ice

3.1.12.2 damp

surface shows a change in colour due to moisture

3.1.12.3 wet

surface is soaked but no significant patches of standing water are visible

3.1.12.4 flooded

standing water patches covering >25% of surface are visible

3.2 Abbreviations

For the purposes of this PAS, the following abbreviations apply.

AST	acceleration, maximum speed and through gear acceleration test level
BK	brake test level
CAV	civilian armoured vehicle
CEP	circle of error probability
DAS	data acquisition system
ESC	electronic stability control
GVM	gross vehicle mass
H	handling test level
P	payload test level
RF	run flat test level
TC	traction control

4 Apparatus

NOTE The following apparatus is used in the test methods described in Clauses 5 to 9.

4.1 *Brake pedal force transducer*, capable of recording brake pedal force in accordance with Table 1.

4.2 *Camera mounts*, easily attached to the test vehicle and capable of securely holding the video cameras (**4.11**).

NOTE For example, clamp type mounts with articulated arms. Applying strong suction mounts to the inner surface of armoured glass should be avoided as it could delaminate the inner laminate surface.

4.3 *Dummy pads*, with a vertical height equal to that of the mass measuring scales (**4.5**) used and of an equivalent stiffness.

NOTE They may also be referred to as levelling mats.

4.4 *Handheld infrared temperature sensor or similar*, capable of measuring the test track surface temperature in accordance with Table 1.

4.5 *Mass measuring scales,* calibrated and capable of measuring the test vehicle mass at each wheel station in accordance with Table 1.

NOTE At least four mass measuring scales should be used for each test.

4.6 *Test ballast*, used to simulate payload in the test vehicle.

NOTE For example, occupants, luggage, and equipment may be represented by sand bags or water dummies.

4.7 *Time based multi-channel recording system [Data Acquisition System (DAS)],* capable of measuring the time history data of the test vehicle's longitudinal velocity (v_x) and GPS position and height in accordance with Table 1, with the facility to allow the test site to trigger flags on the time base. It is also capable of displaying acceleration [in terms of longitudinal acceleration (m/s^2)] determined from the test vehicle longitudinal velocity.

NOTE 1 The system records all necessary test data so that it can be analysed post-test and provide a formal log of results.

NOTE 2 Trigger flags are used to clearly mark critical events on the time base, for example the start of acceleration phase, or passing the 400 m marker.

NOTE 3 Video and audio data may also be recorded by the system (see Table 1).

4.8 *Timer*, capable of measuring time in accordance with Table 1.

4.9 *Track markers*, the specification determined by the test site to clearly mark the track for the test engineers.

NOTE For example, ground paint or cones may be used as track markers.

4.10 *Tyre pressure gauge*, capable of measuring tyre pressure in accordance with Table 1.

4.11 *Video cameras*, ruggedized (water resistant), fixed to camera mounts (**4.2**) capable of capturing video in accordance with Table 1.

NOTE For internal or external mounting and powered by the test vehicle, recording system or batteries.

4.12 *Weather station or similar*, capable of measuring ambient temperature, relative humidity and wind speed in accordance with Table 1.

Table 1 – Test variables to be determined

Variable	Operating range	Recommended maximum overall error
Brake pedal force	(0 – 750) N	±0.1 N
Test track surface temperature (T_{Track})	(0 – 100)°C	±1°C
Mass measuring scales	(0 – 6 000) kg	±5.0 kg
Test vehicle longitudinal velocity (v_x)	(0 – 300) km/h	±1 km/h for $v_x < 100$ km/h ±2 km/h for $v_x \geq 100$ km/h
Longitudinal acceleration	(-20 – +20) m/s^2	±0.1 m/s^2
Timer	—	±1 s
Tyre pressure gauge	(0 – 5) bar	±0.1 bar
Ambient temperature (T_{Amb})	(0 – 60)°C	±1°C
Wind speed (W_{Amb})	(0 – 30) m/s	±1 m/s
Optional		
GPS position (latitude, longitude)	±5.0 m	95% CEP
GPS height	±10 m	95% CEP
Video	at least 25 fps PAL or NTSC 580 lines colour	—
Audio	single internal microphone	—
Relative humidity (RH_{Amb})	(0 – 100)%	±1%
NOTE *The recommended maximum overall error accuracies should be achieved whether the variables are measured or are calculated.*		

5 Payload test method

5.1 Principle

A test vehicle (**3.1.10**) is weighed to ensure the manufacturer's stated maximum axle mass, GVM and tyre and wheel load ratings are not exceeded. The payload test is carried out with all seating positions filled. The payload test assessment is completed prior to any other automotive tests to ensure the test vehicle complies with the stated limits and assessed against the score criteria.

NOTE *The test method describes the procedure for test vehicles with two axles. For test vehicles with more than two axles a similar procedure should be followed.*

5.2 Payload (P) test levels

The payload test level shall be defined in terms of:

- number of occupants;
- occupant mass in kg [for example selected as (75 ±0.5) kg or (100 ±0.5) kg]; and
- total additional payload mass in kg.

NOTE 1 *For example, 4 occupants each weighing 100 kg and 20 kg of total additional payload is test level P-4/100/20; or 6 occupants each weighing 75 kg and 100 kg of total additional payload is test level P-6/75/100.*

NOTE 2 *It should be assumed that occupants occupy the seated positions provided and the total additional payload is stored in the space normally allocated for luggage.*

5.3 Test setup

NOTE *See also* Consolidated code of practice: enforcement weighing of vehicles *[4] for further information.*

5.3.1 The payload test shall be conducted on clean, flat and horizontal hard standing.

NOTE *The ground should be free from stones and provide a stable base for the mass measuring scales (**4.5**).*

5.3.2 The longitudinal slope along the centreline of the test vehicle shall be <1%, measured between any two points 5 m apart.

5.3.3 The lateral slope, measured perpendicular to the centreline shall be <4%.

5.3.4 The surface irregularity of the payload test area, when measured along the centreline and at right angles to the centreline at 2 m intervals, shall be ≤10 mm at any point along the 2 m length.

NOTE *This is assessed by placing a 2 m straight edge along the surface and measuring the height above the surface of the edge at its highest point.*

5.4 Test procedure

5.4.1 Prepare a test log to record data in accordance with Annex A.

5.4.2 Record the required loading configuration in the test log (see Annex A).

5.4.3 Record the tyre load rating from the tyre wall in the test log (see Annex A).

5.4.4 Record the wheel load rating from the wheel test certificate in the test log (see Annex A).

5.4.5 Using the tyre pressure gauge (**4.10**) check and record the tyre pressures cold and adjust to the manufacturer's specified pressure in the test log (see Annex A).

5.4.6 Switch on all the mass measuring scales (**4.5**) and check they are operating correctly.

5.4.7 Position the mass measuring scales and test vehicle such that every wheel being weighed is positioned, so as to ensure that the weight bearing area of the tyre is correctly located, on the active weighing surface of the scale.

5.4.8 Drive the test vehicle onto the mass measuring scales.

5.4.9 For manual vehicles apply the park brake, switch off the engine, engage a low gear and then release all brakes.

NOTE *For automatic or semi-automatic a similar process should be followed.*

5.4.10 Check the positioning to ensure all wheels remain within the active area of the mass measuring scales.

5.4.11 Using the mass measuring scales record the operational kerb mass at each wheel position: A (front near side), B (front off side), C (rear near side), D (rear off side) in the test log (see Annex A).

NOTE *A test ballast (**4.6**) may be used to obtain the correct operational kerb mass.*

5.4.12 In cases where a test vehicle is equipped with more than 2 axles, it might not be possible to weigh all axles of the test vehicle simultaneously. In such cases, the axles are weighed sequentially, starting with axle 1 and 2. In each weighing position, place the dummy pads (**4.3**) under each of the non-weighed wheels so that the test vehicle remains parallel to the ground.

5.4.13 Using the test ballast, load the test vehicle with the specified masses at the passenger and luggage, or equipment positions, to represent the required payload condition (P) defined by the test level (see **5.2**).

5.4.14 Using the mass measuring scales record the operational mass at each wheel position in the test log (see Annex A): E (front near side), F (front off side), G (rear near side), and H (rear off side).

5.4.15 Record the manufacturer's maximum front and rear axle mass as P1 and P2 in the test log (see Annex A).

NOTE *The maximum front and rear axle mass are stated in the operator's manual or displayed on the vehicle axle load plate attached to the test vehicle.*

5.4.16 Record the manufacturer's maximum gross vehicle mass as GVM in the test log (see Annex A).

NOTE *The maximum GVM is stated in the operator's manual or displayed on the vehicle axle load plate attached to the test vehicle.*

5.4.17 Assess the results in accordance with **5.5**.

5.5 Expression of results

5.5.1 When all the data is recorded in accordance with **5.4**, complete the following calculations and enter results in the test log (see Annex A).

- Calculate the combined operational kerb mass for front (K1) and rear axles (K2) in kg:

  $K1 = A + B$ and $K2 = C + D$
- Calculate the combined operational mass for front and rear axles in kg:

  $O1 = E + F$ and $O2 = G + H$
- Calculate the total operational kerb mass (K) in kg:

  $K = K1 + K2$
- Calculate the total operational mass (OM) in kg:

  $OM = O1 + O2$
- Calculate the operational payload available (PA) in kg:

  $PA = GVM - K$

5.5.2 When all calculations have been completed, score the test vehicle in accordance with the criteria given in Table 2 and record the results in the test log (see Annex A).

Table 2 – Payload (P) score criteria

Parameter	Score criteria	
	Pass	Fail
Tyre load rating	operational mass at each wheel position ≤ recorded rating	operational mass at each wheel position > recorded rating
Wheel load rating	operational mass at each wheel position ≤ recorded rating	operational mass at each wheel position > recorded rating
GVM (kg)	GVM ≥ OM	GVM < OM
Axle 1 mass (front) (kg)	P1 ≥ O1	P1 < O1
Axle 2 mass (rear) (kg)	P2 ≥ O2	P2 < O2
Payload (kg)	PA ≥ P	PA < P
NOTE *The results only apply to the design submitted as the test vehicle. If at any stage changes are made to the design, then the results become void until the design changes are submitted for testing.*		

5.6 Report

As a minimum requirement the party completing the testing shall submit a test log and score results in accordance with Annex A.

A certificate shall be issued stating as a minimum:

a) certificate number;

b) test vehicle number/identifier (e.g. build configuration);

c) test dates and report issue date;

d) test party details (organization);

e) test apparatus details and calibration declaration;

f) test level and score;

g) test report number; and

h) statement that the test only applies to the test vehicle configuration tested.

NOTE *In addition, supporting evidence may be included, for example photographs or printouts from the recording systems.*

6 Acceleration, maximum speed, through gear acceleration test methods

6.1 Principle

The test vehicle acceleration is timed from a standing start to assess acceleration.

The test vehicle maximum speed is based on the ability of the test vehicle to achieve a minimum lower speed limit and not exceed the upper speed limit.

The test vehicle acceleration is timed between set speeds to assess through gear acceleration, with the time recorded of the acceleration measurement defined from the positive change in accelerator pedal position to the instant the specified test level speed is achieved.

The performance of the test vehicle is then categorized into one of six performance bands in accordance with Table 3.

NOTE *Where constant speeds are required to start a test then the speed is held for at least 5 s before starting the test.*

6.2 Acceleration, maximum speed, through gear acceleration (AST) test levels

The AST test levels shall be selected in accordance with Table 3.

NOTE 1 *For example, an AST test specified with acceleration (0 – 95) km/h time (≥14 and <20) s, acceleration 400 m time (≥23 and ≤30) s, maximum speed (≥180 and <200) km/h, and through gear acceleration (50 – 110) km/h time (≥14 and <20) s, (80 – 110) km/h time (≥8 and <10) s, (110 – 160) km/h time (≥16 and <19) s is test level AST-1C/2B/3D/4B/5D/6C.*

NOTE 2 *The acceleration is based on two assessments, the test vehicle's ability to accelerate from (0-95) km/h and cover a distance of 400 m from standing start.*

NOTE 3 *The through gear acceleration is based on the test vehicle's ability to accelerate between different speeds, for example, (50 – 110) km/h, (80 – 110) km/h and (110 – 160) km/h.*

Table 3 – AST test levels

Index	Test level	A	B	C	D	E	F
1	Acceleration standing start (0 – 95) km/h Time (s)	≥30	≥20 and <30	≥14 and <20	≥12 and <14	≥9 and <12	<9
2	Acceleration standing start 400 m Time (s)	≥30	≥23 and <30	≥21 and <23	≥19 and <21	≥17 and <19	<17
3	Maximum speed (lower and upper value) (km/h)	≥50 and <100	≥100 and <150	≥150 and <180	≥180 and <200	≥200 and <220	≥220 and <300
4	Through gear acceleration (50 – 110) km/h Time (s)	≥20	≥14 and <20	≥12 and <14	≥10 and <12	≥8 and <10	<8
5	Through gear acceleration (80 – 110) km/h Time (s)	≥20	≥12 and <20	≥10 and <12	≥8 and <10	≥6 and <8	<6
6	Through gear acceleration (110 – 160) km/h Time (s)	≥30	≥19 and <30	≥16 and <19	≥13 and <16	≥10 and <13	<10

6.3 Test setup

6.3.1 The acceleration, maximum speed, and through gear acceleration tests shall be conducted at an ambient temperature of (20 ±15)°C. The wind conditions shall be ≤18 km/h (≤5 m/s), Beaufort scale 3, gentle breeze.

NOTE There are no humidity constraints but this information should be recorded in the test log (see Annex B).

6.3.2 The test track surface shall be smooth, clean and constructed from solid paved concrete or asphalt. The test track surface condition (**3.1.12**) shall be dry or damp. The test shall be postponed when the track is assessed as wet or flooded.

NOTE Track irregularities and undulations, such as dips and large cracks, are unsuitable.

6.3.3 The test track surface temperature shall be (20 ±15)°C.

6.3.4 The track gradient in the direction of travel shall be ≤2%.

NOTE The test track may be level or banked laterally.

6.3.5 Track markers (**4.9**) shall be set out to identify the start and end of the 400 m track.

6.4 Test vehicle preparation

6.4.1 The test vehicle operational kerb mass (**3.1.6**) shall be correctly configured.

6.4.2 The test vehicle shall be ballasted to GVM.

NOTE The test vehicle loading should take into account the mass of the test engineers and test equipment installed on the test vehicle.

6.4.3 The test apparatus in accordance with Clause **4** shall be installed on the test vehicle to facilitate data collection in accordance with **6.5**.

NOTE The installation method may be determined by the test site provided the data collection can be completed successfully.

6.4.4 Using the tyre pressure gauge (**4.10**), the tyre pressures shall be checked cold and adjusted to the manufacturer's specified pressure.

6.4.5 Record the tyre maximum speed rating in the test log (see Annex B).

6.4.6 Record the maximum electronic speed limit, if pre-configured in test vehicle setup, in the test log (see Annex B).

6.4.7 The test vehicle configurable settings shall be set to achieve the optimum performance and recorded in the test log (see Annex B).

6.5 Test procedure

NOTE 1 Testing should conform with the test site local safety procedures at all times.

*NOTE 2 The test procedure described in **6.5** requires test vehicles to complete manoeuvres and to be driven at speeds that could be hazardous.*

NOTE 3 For some tests, observers track side or in a chase vehicle may be used to provide additional feedback information to the test engineer(s) conducting the tests.

NOTE 4 During the test a second test engineer may also occupy the test vehicle to facilitate the recording of observations.

6.5.1 General

6.5.1.1 Prepare a test log to record data in accordance with Annex B.

6.5.1.2 Record the test levels in the test log (see Annex B).

6.5.1.3 Using the weather station (**4.12**) measure and record the ambient temperature, wind speed, and the prevailing wind direction in accordance with **6.3.1** in the test log (see Annex B).

NOTE There are no humidity constraints but this information should be recorded in the test log.

6.5.1.4 Using the infrared temperature sensor (**4.4**) measure and record the test track surface temperature and track surface condition (**3.1.12**) in accordance with **6.3.2** and **6.3.3** in the test log (see Annex B).

6.5.1.5 Drive the test vehicle until at normal engine operating temperature and record the status of any ancillary equipment that might impose any additional loading on the engine, for example air conditioning, headlights, etc., in the test log (see Annex B).

NOTE Ancillary equipment can change the performance of the test vehicle.

6.5.1.6 For automatic transmission vehicles, the test vehicle is held in drive for all tests in **6.5**.

6.5.1.7 For manual transmission vehicles, the gear is that deemed as most suitable for steady state driving for that vehicle type and class. Record the gear at steady state in the test log (see Annex B).

6.5.1.8 Record if the test vehicle is 2wd, 4wd or the drive has been automatically selected by the test vehicle in the test log (see Annex B).

6.5.1.9 During the warm up (see **6.5.1.5**), check the test apparatus is operating correctly.

6.5.1.10 Bring the test vehicle up to a speed of (50 ±1) km/h, as indicated by the test vehicle speedometer, check the test vehicle speed against the recording system (**4.7**) speed readout and record the speed offset in the test log (see Annex B).

NOTE The test vehicle speedometer is not used for data collection but the offset compared to the recording system speed may be recorded as optional information.

6.5.1.11 Bring the test vehicle up to a speed of (80 ±1) km/h, as indicated by the test vehicle speedometer, check the test vehicle speed against the recording system speed readout and record the speed offset in the test log (see Annex B).

6.5.1.12 Bring the test vehicle up to a speed of (110 ±1) km/h, as indicated by the test vehicle speedometer, check the test vehicle speed against the recording system speed readout and record the speed offset in the test log (see Annex B).

6.5.2 Acceleration and maximum speed test procedure

6.5.2.1 Position the front of the test vehicle at the start track marker (**4.9**).

NOTE The test engineer should decide how to identify the datum for the front of the test vehicle, provided it is easily achieved and repeatable.

6.5.2.2 Start the recording system (**4.7**) and check it is recording.

6.5.2.3 Trigger a time base flag and simultaneously accelerate the test vehicle from a standing start.

6.5.2.4 As the test vehicle reaches 95 km/h trigger a time base flag.

6.5.2.5 As the front of the test vehicle passes the 400 m distance track marker trigger a time base flag.

6.5.2.6 As the test vehicle achieves the maximum speed trigger a time base flag.

6.5.2.7 Bring the test vehicle to a halt.

6.5.2.8 Stop the recording system and save the test data.

6.5.2.9 Repeat steps **6.5.2.1** to **6.5.2.8** for subsequent tests, with at least three tests being completed.

6.5.2.10 Average and assess the results in accordance with **6.6**.

6.5.3 Through gear acceleration test procedure

6.5.3.1 Start the recording system (**4.7**) and check it is recording.

6.5.3.2 Position the front of the test vehicle at the start track marker (**4.9**).

6.5.3.3 Bring the test vehicle up to a constant (50 ±1) km/h and hold for at least 5 s.

6.5.3.4 Trigger a time base flag and simultaneously accelerate the test vehicle to (110 ±1) km/h.

NOTE For manual transmission test vehicles no gear changes are allowed during the acceleration phase.

6.5.3.5 As the test vehicle reaches (110 ±1) km/h trigger a time base flag.

6.5.3.6 Bring the test vehicle to a halt.

6.5.3.7 Stop the recording system and save the data.

6.5.3.8 Repeat steps **6.5.3.1** to **6.5.3.7** for subsequent tests, with at least three tests being completed.

6.5.3.9 Assess the results in accordance with **6.6**.

6.5.3.10 Position the front of the test vehicle at the start track marker (**4.9**).

6.5.3.11 Start the recording system (**4.7**) and check it is recording.

6.5.3.12 Bring the test vehicle up to a constant (80 ±1) km/h and hold for at least 5 s.

6.5.3.13 Trigger a time base flag and simultaneously accelerate the test vehicle to (110 ±1) km/h.

NOTE For manual transmission test vehicles no gear changes are allowed during the acceleration phase.

6.5.3.14 As the test vehicle reaches (110 ±1) km/h trigger a time base flag.

6.5.3.15 Bring the test vehicle to a halt.

6.5.3.16 Stop the recording system and save the data.

6.5.3.17 Repeat steps **6.5.3.10** to **6.5.3.16** for subsequent tests, with at least three tests being completed.

6.5.3.18 Assess the results in accordance with **6.6**.

6.5.3.19 Position the front of the test vehicle at the start track marker (**4.9**).

6.5.3.20 Start the recording system (**4.7**) and check it is recording.

6.5.3.21 Bring the test vehicle up to a constant (110 ±1) km/h and hold for at least 5 s.

6.5.3.22 Trigger a time base flag and simultaneously accelerate the test vehicle to (160 ±1) km/h.

***NOTE** For manual transmission test vehicles no gear changes are allowed during the acceleration phase.*

6.5.3.23 As the test vehicle reaches (160 ±1) km/h trigger a time base flag.

6.5.3.24 Bring the test vehicle to a halt.

6.5.3.25 Stop the recording system and save the data.

6.5.3.26 Repeat steps **6.5.3.19** to **6.5.3.25** for subsequent tests, with at least three tests being completed.

6.5.3.27 Assess the results in accordance with **6.6**.

6.6 Expression of results

When the acceleration, maximum speed and through gear acceleration tests have been completed in accordance with **6.5**, analyse the recording system data. Assess the test vehicle in accordance with the score criteria given in Table 4 and record the results in the test log (see Annex B).

6.7 Report

As a minimum requirement the party completing the testing shall submit a test log and score results in accordance with Annex B.

A certificate shall be issued stating as a minimum:

a) certificate number;
b) test vehicle number/identifier (e.g. build configuration);
c) test dates and report issue date;
d) test party details (organization);
e) test apparatus details and calibration declaration;
f) test level and category;
g) test report number; and
h) statement that the test only applies to the test vehicle configuration tested.

***NOTE** In addition, supporting evidence may be included, for example photographs, video or data printouts from the recording system.*

Table 4 – AST score criteria

Test level	Pass	Fail
Acceleration standing start (0 – 95) km/h Time (s)	Recorded average test time within specified band OR Recorded average test time < specified band	Recorded average test time > specified band
Acceleration standing start 400 m Time (s)	Recorded average test time within specified band OR Recorded average test time < specified band	Recorded average test time > specified band
Maximum speed (km/h)	Recorded average test time within specified band	Recorded average test time > specified band OR Recorded average test time < specified band
Through gear acceleration (50 – 110) km/h Time (s)	Recorded average test time within specified band OR Recorded average test time < specified band	Recorded average test time > specified band
Through gear acceleration (80 – 110) km/h Time (s)	Recorded average test time within specified band OR Recorded average test time < specified band	Recorded average test time > specified band
Through gear acceleration (110 – 160) km/h Time (s)	Recorded average test time within specified band OR Recorded average test time < specified band	Recorded average test time > specified band
Tyre maximum speed rating	Recorded maximum average speed ≤ tyre maximum speed rating	Recorded maximum average speed > tyre maximum speed rating
Electronic maximum speed limit	Recorded maximum average speed ≤ electronic maximum speed limit	Recorded maximum average speed > electronic maximum speed limit

7 Handling test method

7.1 Principle

A test vehicle's (**3.1.10**) upper bounds of manoeuvring performance are assessed under braking, acceleration, traction and cornering situations in accordance with Table 5. This includes the test vehicle's handling and stability characteristics, where different driving scenarios are used: track, slalom, lane change and J turn.

The track test is completed at least ten times at a range of speeds deemed appropriate by the test engineer(s). At least six timed laps, in accordance with **7.3.2.1**, are completed at the test vehicle's limit of control. The qualitative results (see Table 7) are recorded in the test log (see Annex C).

The slalom test is completed at least three times in accordance with **7.3.2.2**. The times are recorded in the test log (see Annex C). The fastest three time results are averaged and assessed against the specified test levels (see Tables 5 and 8).

The lane change is completed at least three times in accordance with **7.3.2.3**. The speeds are recorded in the test log (see Annex C). The fastest three speeds are averaged and assessed against the specified test levels (see Tables 5 and 9).

The J turn test is completed at least three times in accordance with **7.3.2.4** and the qualitative results (see Table 10) are recorded in the test log (see Annex C).

***NOTE** Although accepting the effects of the increased mass of the armoured version, the test vehicle is expected to have handling characteristics that closely match those of the soft-skin version.*

7.2 Handling (H) test levels

The handling test levels shall be selected in accordance with Table 5.

***NOTE** For example, a handling test specified with a track test and slalom test time of (≥15 and <20) s is test level H-1/2D; or specified with a track test, slalom test time of (≥25 and <30) s, lane change test speed of (≥90 and <100) km/h and J turn is test level H-1/2B/3E/4.*

Table 5 – Handling (H) test levels

Index		Test level					
		A	B	C	D	E	F
1	Track	—					
2	Slalom Time (s)	≥30	≥ 25 and <30	≥20 and <25	≥15 and <20	≥10 and <15	<10
3	Lane change Speed (km/h)	<60	≥60 and <70	≥70 and <80	≥80 and <90	≥90 and <100	≥100
4	J turn	—					

7.3 Test setup

7.3.1 General

7.3.1.1 The handling tests shall be conducted at (20 ±15)°C. The wind conditions shall be ≤18 km/h (≤5 m/s), Beaufort scale 3, gentle breeze.

***NOTE** There are no humidity constraints but this information should recorded in the test log (see Annex C).*

7.3.1.2 The test track surface shall be smooth, clean and constructed from solid paved concrete or asphalt.

***NOTE** Track irregularities and undulations, such as dips and large cracks, are unsuitable.*

7.3.1.3 The test track surface condition (**3.1.12**) shall be dry or damp. The test shall be postponed when the track is assessed as wet or flooded.

7.3.1.4 The test track surface temperature shall be (20 ±15)°C.

7.3.2 Course layouts

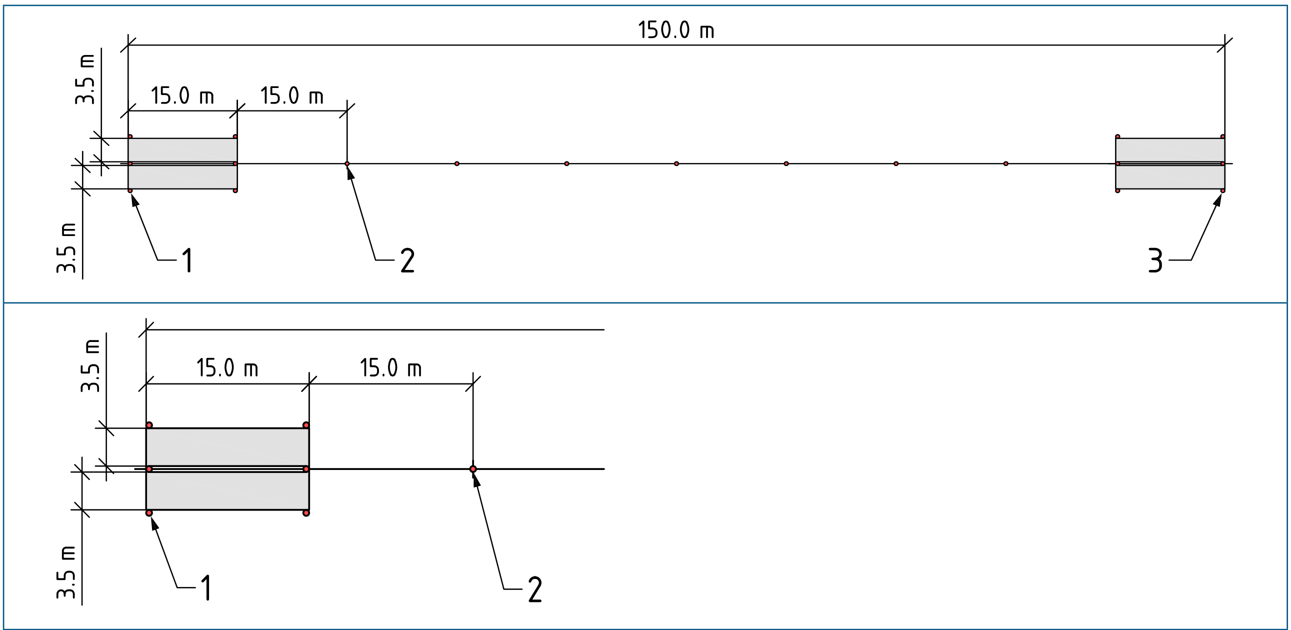
7.3.2.1 Track course

The track course shall include left and right bends, inclines of ≤3%, declines of ≤3% and higher speed short straight sections to achieve rapid acceleration up to mid-range speeds of (80 – 95) km/h then deceleration under braking into corners. Apart from the inclines and declines the track gradient in the direction of travel shall be ≤2%. The track start and finish points shall be clearly marked with track markers (**4.9**).

7.3.2.2 Slalom course

The slalom test course shall be setup in accordance with Figure 1. The track gradient in the direction of travel shall be ≤2%.

Figure 1 – Slalom course



Key

1 Start gate, entry left or right

2 Track markers equally spaced marking 4 complete slaloms

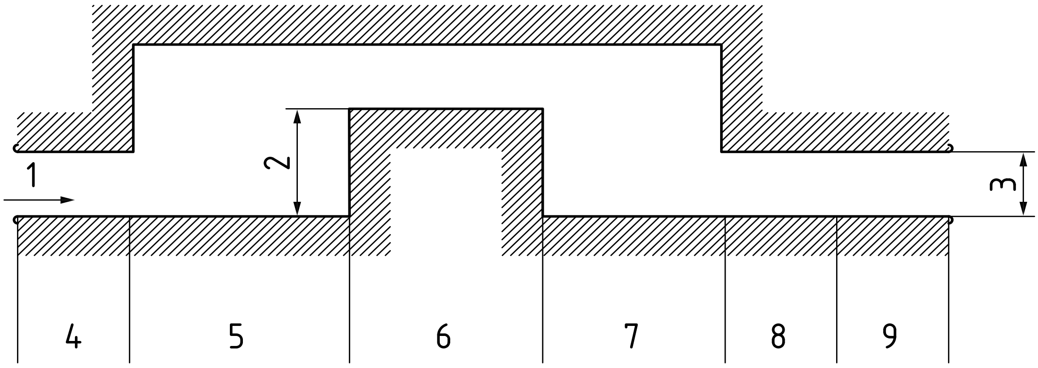
3 Finish gate

7.3.2.3 Lane change course

The lane change course shall be setup in accordance with BS ISO 3888-1:1999 (see Figure 2 and Table 6). The track gradient in the direction of travel shall be ≤2%.

***NOTE** A lane change is defined as a deliberate and substantial shift in the lateral position of a test vehicle in relation to its original path.*

Figure 2 – Lane change course



Key

1 Driving direction
2 Lane offset
3 Width

4 Section 1
5 Section 2
6 Section 3

7 Section 4
8 Section 5
9 Section 6

SOURCE: BS ISO 3888-1:1999, Figure 1

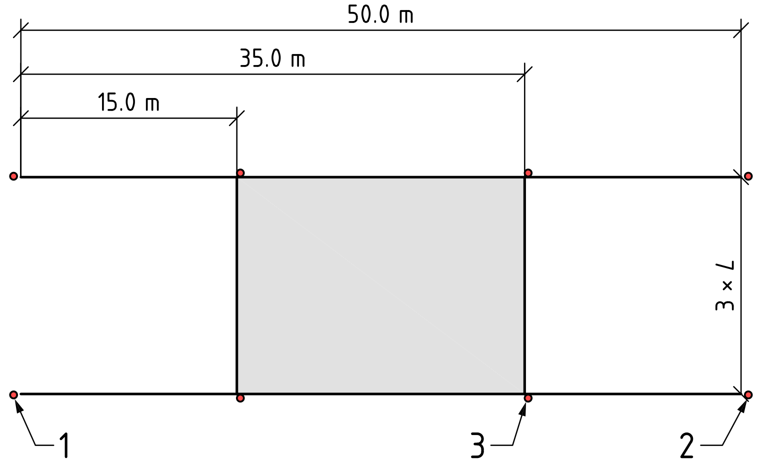
Table 6 – Lane change course dimensions

Section	Length m	Lane offset m	Width m
1	15	—	1.1 × vehicle width + 0.25
2	30	—	—
3	25	3.5	1.2 × vehicle width + 0.25
4	25	—	—
5	15	—	1.3 × vehicle width + 0.25
6	15	—	1.3 × vehicle width + 0.25

7.3.2.4 J turn course

The J turn course shall be set up in accordance with Figure 3. The track gradient in the direction of travel shall be ≤2%.

Figure 3 – J turn course



Key

1 Start gate

2 Finish gate

3 Track markers marking course

L Length of test vehicle

NOTE *All dimensions with tolerance ±0.1 m.*

7.4 Test vehicle preparation

7.4.1 The test vehicle operational kerb mass (**3.1.6**) shall be correctly configured.

7.4.2 The test vehicle shall be ballasted to GVM.

NOTE *The test vehicle loading should take into account the mass of the test engineer(s) and test equipment installed on the test vehicle.*

7.4.3 The test apparatus in accordance with Clause **4** shall be installed on the test vehicle to facilitate data collection in accordance with **7.5**.

NOTE 1 *The installation method may be determined by the test site provided the data collection can be completed successfully.*

NOTE 2 *The test vehicle loading should take into account the mass of the test engineer(s) and test equipment installed on the test vehicle.*

7.4.4 Using the tyre pressure gauge (**4.10**) the tyre pressures shall be checked cold and adjusted to the manufacturer's specified pressure.

7.5 Test procedure

NOTE 1 *Testing should conform with the test site local safety procedures at all times.*

NOTE 2 *The test procedure described in **7.5** requires test vehicles to complete manoeuvres and to be driven at speeds that could be hazardous.*

NOTE 3 *For some tests, observers track side or in a chase vehicle may be used to provide additional feedback information to the test engineer(s) conducting the tests.*

NOTE 4 *During the test a second test engineer may also occupy the test vehicle to facilitate the recording of observations.*

7.5.1 General

7.5.1.1 Prepare a test log to record data in accordance with Annex C.

7.5.1.2 Record the test levels in the test log (see Annex C).

7.5.1.3 Prepare the test vehicle in accordance with **7.4**.

7.5.1.4 Using the weather station (**4.12**) measure and record the temperature, wind speed, and the prevailing wind direction in accordance with **7.3.1.1** in the test log (see Annex C).

NOTE There are no humidity constraints but this information should be recorded in the test log.

7.5.1.5 Using the infrared temperature sensor (**4.4**) measure and record the test track surface temperature and track surface condition (**3.1.12**) in accordance with **7.3.1.3** and **7.3.1.4** in the test log (see Annex C).

7.5.1.6 Drive the test vehicle through a warm-up period until at normal engine operating temperature and record the status of any ancillary equipment that might impose any additional loading on the engine, for example air conditioning, headlights, etc., in the test log (see Annex C)

NOTE Ancillary equipment can change the performance of the test vehicle.

7.5.1.7 During the warm-up, check the test apparatus is operating correctly.

7.5.2 Track test procedure

7.5.2.1 Position the test vehicle at the start of the course (see **7.3.2.1**).

7.5.2.2 Start the recording system (**4.7**) and check it is recording.

7.5.2.3 Complete at least ten timed laps at a range of speeds deemed appropriate by the test engineer to assess the qualitative observations described in Table 7. Complete at least six timed laps at a speed where the test engineer feels the test vehicle is at the limit of its handling capability.

NOTE 1 The timed laps start with a rolling start and the test vehicle is not stopped during the test. The timing is based on the front of the test vehicle passing the start and end track marker and triggering time base flags on the recording system.

NOTE 2 For the higher speeds and limit of handling, the objective is not to achieve the fastest run time but to consistently place the test vehicle close to its limits of handling capability.

7.5.2.4 Bring the test vehicle to a halt.

7.5.2.5 Stop the recording system and save the data.

7.5.2.6 Record the qualitative observations in accordance with Table 7 in the test log (see Annex C).

NOTE The qualitative observations are completed once by the test engineer(s).

7.5.2.7 Assess the results in accordance with **7.6**.

7.5.3 Slalom test procedure

7.5.3.1 Start the recording system (**4.7**) and check it is recording.

7.5.3.2 Position the front of the test vehicle at the start gate.

7.5.3.3 Complete at least three timed passes though the slalom course (see **7.3.2.2**).

NOTE The timing is based on the front of the test vehicle passing the start and end marker and triggering time base flags on the recording system.

7.5.3.4 Record the times in the test log (see Annex C).

7.5.3.5 Bring the test vehicle to a halt.

7.5.3.6 Stop the recording system and save the data.

7.5.3.7 Record the average of the three fastest test times in the test log (see Annex C).

7.5.3.8 Assess the results in accordance with **7.6**.

7.5.4 Lane change test procedure

7.5.4.1 Start the recording system (**4.7**) and check it is recording.

7.5.4.2 Position the front of the test vehicle at the start of the course.

7.5.4.3 Complete at least three passes though the course (see **7.3.2.3**) maintaining the constant maximum achievable speed ±3 km/h.

7.5.4.4 Bring the test vehicle to a halt.

7.5.4.5 Stop the recording system and save the data.

7.5.4.6 Record the entry and exit speeds of each pass in the test log (see Annex C).

NOTE The test speed is determined as the average of the entry and exit speeds.

7.5.4.7 Record the average of the three fastest test speeds in the test log (see Annex C). The spread of the three speeds is ±3 km/h.

7.5.4.8 Assess the results in accordance with **7.6**.

7.5.5 J turn test procedure

7.5.5.1 Start the recording system (**4.7**) and check it is recording.

7.5.5.2 Position the front of the test vehicle at the start gate.

7.5.5.3 Complete at least three timed J turns though the course (see **7.3.2.4**). The spread of the three times is ±3 s.

NOTE *The timing is based on the front of the test vehicle passing the start and end marker and triggering time base flags on the recording system.*

7.5.5.4 Record the qualitative observations in accordance with Table 10 in the test log (see Annex C).

NOTE 1 *The qualitative observations are completed once by the test engineer(s).*

NOTE 2 *The times are recorded to demonstrate test consistency.*

7.5.5.5 Bring the test vehicle to a halt.

7.5.5.6 Stop the recording system and save the data.

7.5.5.7 Assess the results in accordance with **7.6**.

7.6 Expression of results

When the track tests have been completed in accordance with **7.5.2**, assess the test vehicle in accordance with the score criteria given in Table 7 and record the results in the test log (see Annex C).

When the slalom test has been completed in accordance with **7.5.3**, assess the test vehicle in accordance with the score criteria given in Table 8 and record the results in the test log (see Annex C).

When the lane change test has been completed in accordance with **7.5.4**, assess the test vehicle in accordance with the score criteria given in Table 9 and record the results in the test log (see Annex C).

When the J turn test has been completed in accordance with **7.5.5**, assess the test vehicle in accordance with the score criteria given in Table 10 and record the results in the test log (see Annex C).

Table 7 – Track test score criteria

Parameter	Score criteria			
	1	2	3	4
Handling balance	Requires constant adjustment, unpredictable, hard work			Predictable, consistent, easy and safe
Grip level	Relatively slow corner speeds and long braking distances			Highly capable for its class
Braking response	Significant steering correction required			No path deviation
Power change response	Difficult to balance mid-corner and control exit acceleration			Useful mid-corner control and stable exit acceleration
Turn-in response	Unpredictably strong or weak, non-linear or slow to respond			Swift and proportional response
Roll control	Undue risk of rollover or perception of instability			Low, swiftly adopted roll angle and no control or stability issues
Pitch control	Excessive pitch angle causing discomfort			Low, swiftly adopted pitch angle
Straight line stability	Significant steering corrections required			No steering corrections required
Steering effort level	Difficult to drive at speed, possesses catch-up			Easy to control at speed
Steering feel	No sense of cornering speed, undue vibrations or excess friction			Perfectly indicates cornering speed and the limit of handling
ESC and TC system performance	Early, excessive and aggressive intervention			No hindrance to rapid progress whilst activating appropriately
Driver controls ergonomics	Awkward to use, mismatched effort levels			Easy operation with informative effort levels
NOTE *See the commentary on* ***7.6*** *for further explanations of these parameters.*				

Table 8 – Slalom test score criteria

Parameter	Pass	Fail
Average time to complete slalom (s)	Recorded test time within specified band OR Recorded test time < specified band	Recorded test time > specified band

Table 9 – Lane change test score criteria

Parameter	Pass	Fail
Average speed to complete lane change (km/h)	Recorded test speed within specified band OR Recorded test speed < specified band	Recorded test speed > specified band

Table 10 – J turn test score criteria

Parameter	Score criteria			
	1	2	3	4
Reverse steering response	Unpredictably strong or weak, slow to respond, difficult to control			Swift and proportional response, easy to control
Roll control	Undue risk of rollover or perception of instability			Low, swiftly adopted roll angle and no control or stability issues
Steering effort level	Difficult to drive at speed, possesses catch-up			Easy to control at speed
Steering feel	No sense of cornering speed, undue vibrations or excess friction			Perfectly indicates cornering speed and the limit of handling
ESC and TC system performance	Early, excessive and aggressive intervention			No hinderance to rapid progress
Driver controls ergonomics	Awkward to use, mismatched effort levels			Easy operation withinformative effort levels
***NOTE** See the commentary on **7.6** for further explanations of these parameters.*				

COMMENTARY on 7.6

Handling balance

Handling balance describes the degree to which a test vehicle under or oversteers in response to increased lateral acceleration. A neutral balance means that the same steering input is used for a corner irrespective of the speed the corner is negotiated. If the steering input needs to increase for higher corner speeds then the test vehicle is understeering. If the steering input needs to decrease at higher corner speeds then the test vehicle is oversteering. In a transient sense, when turning in or out of a corner, the handling balance might be different from the steady state performance – a test vehicle might oversteer in response to fast turn-in and then settle to understeer in steady conditions.

Assessment – Consider the changes in required steering input when driving with a balanced throttle at increasing speed through each corner. A good vehicle is predictable, consistent, safe and does not overwork or stress the test engineer, whilst a bad vehicle requires a lot of adjustment, varies greatly in required input with corner speed and is likely to overwork and stress the test engineer.

Grip level

Grip level refers to the highest cornering speeds and braking rates attainable.

Assessment – Judged by the forces felt as a result of lateral and longitudinal accelerations during the fastest laps. A good vehicle is highly capable in relation to other vehicles in its class. A bad vehicle requires greatly increased braking distances and/or slow cornering speeds.

Braking response

Braking response refers to the test vehicle's response to inputs at the brake pedal of various magnitudes and rates during various cornering scenarios.

Assessment – Consider the magnitude of any path deviations and necessary steering corrections in response to alternative brake application styles. A wide range of vehicle speeds, lateral accelerations and brake applications should be used during the assessment, not just those employed whilst driving the fastest laps. A good vehicle allows braking in a corner without changing its line. A bad vehicle causes severe deviation from the intended path when braking in a corner.

Power change response

Power change response refers to the test vehicle's response to inputs of various magnitude and rate to the accelerator pedal during various cornering scenarios.

Assessment – Consider the magnitude of any path deviations and necessary steering corrections in response to throttle applications when balancing the test vehicle mid-corner and when accelerating out of the corner. A wide range of engine speeds and throttle applications styles should be used during the assessment, not just those employed whilst driving the fastest laps. A good vehicle provides a smooth increase and decrease in speed for small inputs in a corner and accelerates out of a turn without deviation from its path. A bad vehicle does not respond at all or responds violently to small throttle inputs in a corner and causes a severe change in line when accelerating out of a turn.

Turn-in response

Turn-in response is the magnitude and timing of the response to a steering input – the gain and delay, respectively. It also considers the proportionality of the gain to inputs of various magnitude – the linearity.

Assessment – Consider the size of the test vehicle response to the input – is it weak or strong and is it linear – and the time it takes to provide the response – is it slow or rapid. A good vehicle provides a reasonably quick response without feeling nervous and difficult to control, and is linear and therefore predictable, and without noticeable delay. A bad vehicle is either so responsive as to be difficult to control or so weak as to require unusually large steering inputs, and might also be unpredictable and slow in response.

Roll control

Roll control is the degree to which the body rolls during corners and the rate at which it changes angle.

Assessment – Consider the roll angle adopted by the test vehicle at maximum cornering speeds. Consider also the rate at which this angle is adopted and the effect the rate and angle have on the cornering performance of the test vehicle and the test engineer's perception of safety. A good vehicle adopts a low roll angle, whilst still providing adequate perception of cornering, which develops relatively quickly without causing undue vehicle control issues or discomfort for the test engineer. A bad vehicle rolls so much as to cause concern to the test engineer for their safety or might present a risk of rollover that is unexpected for the class of vehicle. A bad vehicle might also take a long time to roll such that the test engineer needs to turn in earlier than expected in order for steady cornering conditions to occur at the right time.

Pitch control

Pitch control is the degree to which the body pitches when braking or accelerating and the rate at which it changes angle.

Assessment – Consider the pitch angle adopted by the test vehicle when braking or accelerating. A good vehicle adopts a low pitch angle that develops relatively quickly without causing alarm or discomfort for the test engineer. A bad vehicle pitches so much as to cause discomfort for the test engineer.

Straight line stability

Straight line stability is the degree to which the test vehicle maintains a straight path when driving along level ground with the steering straight ahead and at constant speed.

Assessment – Consider the steering activity required just to maintain a straight line. Consider the test vehicle's sensitivity to perturbations from the track or whether it requires a fixed input to the steering in order to travel in a straight line. A good vehicle is undisturbed by the relatively small perturbations from a handling course and drives in a straight line without correction by the test engineer. A bad vehicle pulls, weaves or is fidgety.

Steering effort level

Steering effort level is the magnitude of the forces developed between the test engineer's hands and the steering wheel when steering.

Assessment – Judged by the forces felt in the hands when driving around the lap. A good vehicle is easy to drive and not tiring, but still provides some resistance so that control is stable. A bad vehicle has heavy steering or steering that is so light it is difficult to maintain a stable steering wheel, or it might exhibit catch-up where a lack of steering assistance temporarily renders the steering unusually heavy.

Steering feel

Steering feel is the effort level in the steering wheel as a function of cornering speed, and a description of the information that is presented to the test engineer, both desirable and undesirable, such as the presence of friction (friction feel), road surface texture information (road feel), vibration due to wheel imbalance (nibble) or forces due to roadwheel impacts (kickback).

Assessment – Consider the degree to which the effort at the steering wheel matches the lateral acceleration level. Consider also the presence of other vibration content and any masking effects. A good vehicle gives the test engineer feedback on cornering speed and indicates the reduction in steering forces that occur as the limit of handling is approached. It also provides the test engineer with some information concerning the surfaces being driven over without being intrusive. A bad vehicle does not give the test engineer feedback on cornering speed or the approach of the limit of handling. It contains intrusive vibration signals and possess a highly damped feel due to excess friction levels.

ESC and TC system performance

ESC and TC system performance is the ability of the electronic stability and traction control systems to perform their intended function.

Assessment – Consider the ability of the systems to allow the test engineer to maintain pace and to quickly return full control after intervention. A good vehicle allows the test engineer to maintain pace smoothly and continuously without feeling unduly hindered. A bad vehicle intervenes early, excessively and aggressively, seriously hindering progress, or it might intervene late, causing a delay or unsafe condition. It is also slow to give control back to the test engineer.

Driver controls ergonomics

Driver controls ergonomics is the positioning, operational kinematics and effort level of the test engineer's primary controls (steering wheel, clutch, brake and throttle pedals).

Assessment – Consider the comfort and ease of using the controls whilst conducting fast laps. A good vehicle has sufficient seat adjustment and well positioned controls to allow the test engineer easy and rapid use without interference. The controls are balanced in effort with each other and of expected stroke length and direction. A bad vehicle is awkward to operate with badly sited controls that have either too light, too heavy or widely varying effort levels, stroke lengths that are too long or too short and that move along badly aligned paths.

Reverse steering response

Reverse steering response is the magnitude and timing of the response to a steering input - the gain and delay, respectively. It also considers the proclivity of the steering to self-steer towards the lock position.

Assessment – Consider the size of the test vehicle response to the input – is it weak or strong – and the time it takes to provide the response - is it slow or rapid. A good vehicle provides a reasonably quick response without feeling nervous and difficult to control, and without noticeable delay. It also provides some assistance in reverse steering that lessens the effort required of the test engineer. A bad vehicle is either so responsive as to be difficult to control or so weak as to require unusually large steering inputs, and might also be unpredictable and slow in response. It might also fail to provide any self-steering assistance or drive so quickly towards the lock position as to be difficult to control smoothly and with the minimum of effort.

7.7 Report

As a minimum requirement the party completing the testing shall submit a test log and score results in accordance with Annex C.

A certificate shall be issued stating as a minimum:

a) certificate number;

b) test vehicle number/identifier (e.g. build configuration);

c) test dates and report issue date;

d) test party details (organization);

e) test apparatus details and calibration declaration;

f) test level and category;

g) test report number; and

h) statement that the test only applies to the test vehicle configuration tested.

NOTE *In addition, supporting evidence may be included, for example photographs, video or data printouts from the recording system.*

8 Brake test method

8.1 Principle

A test vehicle's (**3.1.10**) braking performance is assessed by testing how it copes with the additional weight of armour and operational equipment fitted to the test vehicle up to GVM by accelerating up to a defined test speed and braking under constant longitudinal deceleration (5.0 ±0.1) m/s² up to 15 times (brake heating test procedure only) in continuous cycles and assessed against the score criteria. Part of the assessment assesses the ability of the brakes to dissipate heat resulting from repeated brake applications.

The performance prescribed for braking systems is based on the stopping distance and the mean longitudinal acceleration (fully developed deceleration). The performance of a braking system is determined by measuring the stopping distance in relation to the initial speed of the test vehicle and/or by measuring the mean fully developed deceleration during the test.

Commentary on 8.1

The stopping distance is the distance covered by the test vehicle from the moment when the test engineer begins to press the brake pedal until the moment when the test vehicle stops; the initial speed is the speed at the moment when the test engineer begins to actuate the control of the braking system; the initial speed is not less than 98% of the prescribed speed for the test in question.

The mean fully developed deceleration (d_m) is calculated as the deceleration averaged with respect to distance over the interval v_b to v_e, according to the following formula:

$$d_m = \frac{v_b^2 - v_e^2}{25.92\,(s_e - s_b)}$$

Where:

v_o = *initial test vehicle speed in km/h*

v_b = *test vehicle speed at 0.8 v_o in km/h*

v_e = *test vehicle speed at 0.1 v_o in km/h*

s_b = *distance travelled between v_o and v_b in m*

s_e = *distance travelled between v_o and v_e in m*

8.2 Brake (BK) test levels

The brake test level shall be 15 stops.

NOTE *Where a test vehicle is intended for a demanding, high speed pursuit role, the party requesting testing might wish to consider a more demanding test with a higher number of stops and/or using an alternative method.*

8.3 Test setup

8.3.1 The brake test shall be conducted at (20 ±15)°C. The wind conditions shall be ≤18 km/h (≤5 m/s), Beaufort scale 3, gentle breeze.

NOTE *There are no humidity constraints but this information should be recorded in the test log (see Annex D).*

8.3.2 The test track surface shall be smooth, clean and constructed from solid paved concrete or asphalt. The test track surface condition (**3.1.12**) shall be dry or damp. The test shall be postponed when the track is assessed as wet or flooded.

NOTE *Track irregularities and undulations, such as dips and large cracks, are unsuitable.*

8.3.3 The test track surface temperature shall be (20 ±15)°C. The track gradient in the direction of travel shall be ≤2%.

8.3.4 The track layout shall allow the test vehicle to be accelerated up to the test speed and brake under constant longitudinal deceleration (5.0 ±0.1) m/s² 15 times in continuous cycles.

8.4 Test vehicle preparation

8.4.1 The test vehicle operational kerb mass (**3.1.6**) shall be correctly configured.

8.4.2 The test vehicle shall be ballasted to GVM.

NOTE *The test vehicle loading should take into account the mass of the test engineer(s) and test equipment installed on the test vehicle.*

8.4.3 The test apparatus in accordance with Clause **4** shall be installed on the test vehicle to facilitate data collection in accordance with **8.5** and determine the mean fully developed deceleration (d_m) and stopping distance in accordance with **8.6**.

NOTE The installation method may be determined by the test site provided the data collection can be completed successfully.

8.4.4 The brake fluid shall be changed and a new set of original equipment brake pads fitted.

8.4.5 The brake pads shall be bedded in accordance with the recommendations of the vehicle manufacturer.

8.4.6 Using the tyre pressure gauge (**4.10**) the tyre pressures shall be checked cold and adjusted to the manufacturer's specified pressure.

8.5 Test procedure

NOTE 1 Testing should conform with the test site local safety procedures at all times.

*NOTE 2 The test procedure described in **8.5** requires test vehicles to complete manoeuvres and to be driven at speeds that could be hazardous.*

NOTE 3 For some tests, observers track side or in a chase vehicle may be used to provide additional feedback information to the test engineer(s) conducting the tests.

NOTE 4 During the test a second test engineer may also occupy the test vehicle to facilitate the recording of observations.

8.5.1 General

8.5.1.1 Prepare a test log to record data in accordance with Annex D.

8.5.1.2 Prepare the test vehicle in accordance with **8.4**.

8.5.1.3 Using the infrared temperature sensor (**4.4**) measure and record the test track surface temperature and track surface condition (**3.1.12**) in accordance with **8.3.2** and **8.3.3** in the test log (see Annex D).

8.5.2 Brake cold performance test procedure

8.5.2.1 Start the recording system (**4.7**) and check it is recording.

8.5.2.2 Accelerate the test vehicle to its maximum speed (V_{max}) or 100 km/h, whichever is the lower.

*NOTE 1 The maximum speed V_{max} is determined in **6.5.2**.*

NOTE 2 The maximum speed or (100 ±2) km/h should be maintained for at least 2 s.

8.5.2.3 Select neutral and depress the clutch (if applicable), apply the foot brake as fast as possible to achieve maximum braking or a maximum brake pedal force of 500 N. Once maximum braking is reached, keep the brake pedal force as constant as possible until the test vehicle comes to a halt.

8.5.2.4 Record the brake pedal force applied, mean fully developed deceleration and stopping distance in the test log (see Annex D).

8.5.2.5 Stop the recording system and save the data.

8.5.2.6 Assess the results in accordance with **8.6**.

8.5.3 Brake heating test procedure

8.5.3.1 Start the recording system (**4.7**) and check it is recording.

8.5.3.2 Accelerate the test vehicle as quickly as possible to a test speed (V1) equal to $0.8*V_{max}$.

NOTE If $0.8*V_{max}$ is less than 80 km/h then the test speed is the lower of V_{max} or 80 km/h. If $0.8* V_{max}$ exceeds 120 km/h, the test speed is 120 km/h.

8.5.3.3 Select neutral and depress the clutch (if applicable), apply the footbrake such that the test vehicle slows, at mean longitudinal deceleration of (5.0 ±0.1) m/s^2 to a speed (V2) equal to 0.5*V1.

NOTE Two preliminary tests may be carried out to determine the appropriate brake pedal force.

8.5.3.4 At a time of 45 s after the initiation of the previous brake application repeat **8.5.3.2** and **8.5.3.3** until 15 brake applications have been completed.

NOTE If the characteristics of the test vehicle make it impossible to abide by the 45 s duration prescribed, the duration may be increased; in any event, in addition to the time necessary for braking and accelerating the test vehicle, a period of 10 s is allowed in each cycle for stabilizing the speed V1.

8.5.3.5 Stop the recording system and save the data.

8.5.3.6 Assess the results in accordance with **8.6**.

8.5.4 Brake hot performance test procedure

8.5.4.1 Immediately after completion of the brake heating test procedure (see **8.5.3**), start the recording system (**4.7**), check it is recording and accelerate the test vehicle to V_{max} or 100 km/h, whichever is the lower.

***NOTE** This speed, ±2 km/h should be maintained for at least 2 s.*

8.5.4.2 Select neutral and depress the clutch (if applicable) and apply the footbrake as quickly as possible to the same brake pedal force ±5 N as was recorded in the cold performance test (see **8.5.2.3**). Keep the brake pedal force as constant as possible until the test vehicle comes to a halt.

8.5.4.3 Stop the recording system and save the data.

8.5.4.4 Assess the results in accordance with **8.6**.

8.5.5 Brake recovery test procedure

8.5.5.1 Immediately after the brake hot performance test (see **8.5.4**), accelerate the test vehicle as fast as possible to V_{max} or 50 km/h, whichever is the lower.

***NOTE** This speed, ± 2 km/h should be maintained for at least 10 s.*

8.5.5.2 Apply the brakes such that the test vehicle is brought to rest at a mean deceleration of (3.0 ±0.1) m/s^2.

8.5.5.3 Accelerate the test vehicle as fast as possible to V_{max} or 50 km/h, whichever is lower.

8.5.5.4 Drive at a constant speed for a distance of (1.5 ±0.1) km.

8.5.5.5 Apply the brakes such that the test vehicle is brought to rest at a mean deceleration of (3.0 ±0.1) m/s^2.

8.5.5.6 Repeat steps **8.5.5.1** to **8.5.5.5** four times.

8.5.5.7 Asses the results in accordance with **8.6**.

8.5.6 Brake recovery performance test procedure

8.5.6.1 Immediately after completion of the brake recovery test (see **8.5.5**), accelerate the test vehicle to V_{max} or 100 km/h, whichever is the lower.

***NOTE** This speed, ± 2 km/h should be maintained for at least 2 s.*

8.5.6.2 Select neutral and depress the clutch (if applicable) and apply the footbrake as quickly as possible to the same brake pedal force ±5 N as was recorded for the cold performance test (see **8.5.2.3**). Keep the brake pedal force as constant as possible until the test vehicle comes to a halt.

8.5.6.3 Stop the recording system and save the data.

8.5.6.4 Assess the results in accordance with **8.6**.

8.6 Expression of results

When the brake tests have been completed in accordance with **8.5**, score the test vehicle in accordance with the criteria given in Table 11 and record the results in the test log (see Annex D).

A quantitative assessment shall be completed in accordance with Table 11 for the brake cold performance, brake hot performance and brake recovery performance.

A qualitative assessment shall be completed in accordance with Table 11 for the brake heating test procedure and brake recovery test procedure.

8.7 Report

As a minimum requirement the party completing the testing shall submit a test log and score results in accordance with Annex D.

A certificate shall be issued stating as a minimum:

a) certificate number;
b) test vehicle number/identifier (e.g. build configuration);
c) test dates and report issue date;
d) test party details (organization);
e) test apparatus details and calibration declaration;
f) test level and category;
g) test report number; and
h) statement that the test only applies to the test vehicle configuration tested.

***NOTE** In addition, supporting evidence may be included, for example photographs, video or data printouts from the recording system.*

Table 11 – Braking score criteria

Parameter	Score criteria			
	1	2	3	4
Brake cold performance	d_m<5 m/s² or stopping distance >0.15V_1 + V_1^2/130			d_m≥5 m/s² AND stopping distance ≤0.15V_1 + V_1^2/130
Brake hot performance	d_m (hot) < 4 m/s² or d_m (hot)< 0.6 × d_m (cold)	d_m (hot)≥0.6*d_m (cold) and <0.7*d_m (cold)	d_m (hot) ≥ 0.7*d_m (cold) and < 0.8 × d_m (cold)	d_m (hot)> 0.9 × d_m (cold)
Brake recovery performance	d_m (recovery) ≤ 0.7*d_m (cold) OR >1.5*d_m (cold)			d_m (recovery) > 0.7*d_m (cold) AND ≤1.5*d_m (cold)
Smoke/Fire A)	Visible flames			No visible smoke or flames
Heat damage B)	Severe heat damage to caliper dust seals, neighbouring rubber components, ball joint boot, ABS wiring harness, pad-wear sensors	Minor heat damage to caliper dust seals, neighbouring rubber components, ball joint boot, ABS wiring harness, pad-wear sensors	Scorch/singe damage to caliper dust seals, neighbouring rubber components, ball joint boot, ABS wiring harness, pad-wear sensors	No heat damage to caliper dust seals, neighbouring rubber components, ball joint boot, ABS wiring harness, pad-wear sensors
Brake pad detachment/ Delamination B)	Complete delamination or separation of the pad material from the back plate	Minor delamination of pad material, or separation from the back plate. Minor central cracks across the pad material are acceptable	Cracking of pad material around the back plate. Minor central cracks across the pad material are acceptable	No delamination or separation of pad material. Minor central cracks across the pad material are acceptable
Front brake degradation B)	Substantial crumbling and cracking to pad material	Moderate crumbling and cracking to pad material	Minor crumbling and cracking to pad material	No crumbling and cracking to pad material
Rear brake degradation B)	Substantial crumbling and cracking to pad material	Moderate crumbling and cracking to pad material	Minor crumbling and cracking to pad material	No crumbling and cracking to pad material
Vibration through steering wheel A)	Substantial vibration, where the vehicle is uncontrollable	Moderate	Minor	No significant change in vibration

*NOTE d_m = mean fully developed deceleration calculated in accordance with **8.1**.*
A) Qualitative assessment criteria used during brake heating test procedure and brake recovery test procedure.
B) Requires disassembling of front and rear brake assemblies for inspection.

9 Run flat test method

9.1 Principle

The run flat test assesses the ability of the run flat system of a test vehicle to complete an escape at a specified speed over a specified distance loaded to GVM. The run flat test includes three phases: the manoeuvre phase, escape phase and liaison phase, in this order.

The test is completed twice, the first test is with one front tyre only deflated, the second test is with one rear tyre only deflated and assessed in accordance with Table 13. The choice on which tyre to deflate is dictated by the highest tyre loading determined during the payload test (see Clause **5**). Each phase starts within 60 s (including any inspection time) from the end of the previous phase.

9.2 Run flat (RF) test level

The run flat test shall be conducted in accordance with Table 12.

Table 12 – Run flat (RF) test level

	Distance km	Run flat speed
Manoeuvre phase	1	Maximum speed achievable on manoeuvre circuit
Escape phase	3	60% of maximum test vehicle speed as determined in maximum speed test, or 160 km/h (whichever is less)
Liaison phase	100 or point of failure, whichever is the lesser	30% of maximum test vehicle speed as determined in maximum speed test, or 80 km/h (whichever is less)

9.3 Test setup

9.3.1 General

9.3.1.1 The run flat test shall be conducted at (20 ±15)°C. The wind conditions shall be ≤18 km/h (≤5 m/s), Beaufort scale 3, gentle breeze.

NOTE *There are no humidity constraints but this information should be recorded in the test log (see Annex E).*

9.3.1.2 The track surface shall be smooth, clean and constructed from solid paved concrete or asphalt.

NOTE *Track irregularities and undulations, such as dips and large cracks, are unsuitable.*

9.3.1.3 The test track surface condition (**3.1.12**) shall be dry or damp. The test shall be postponed when the track is assessed as wet or flooded.

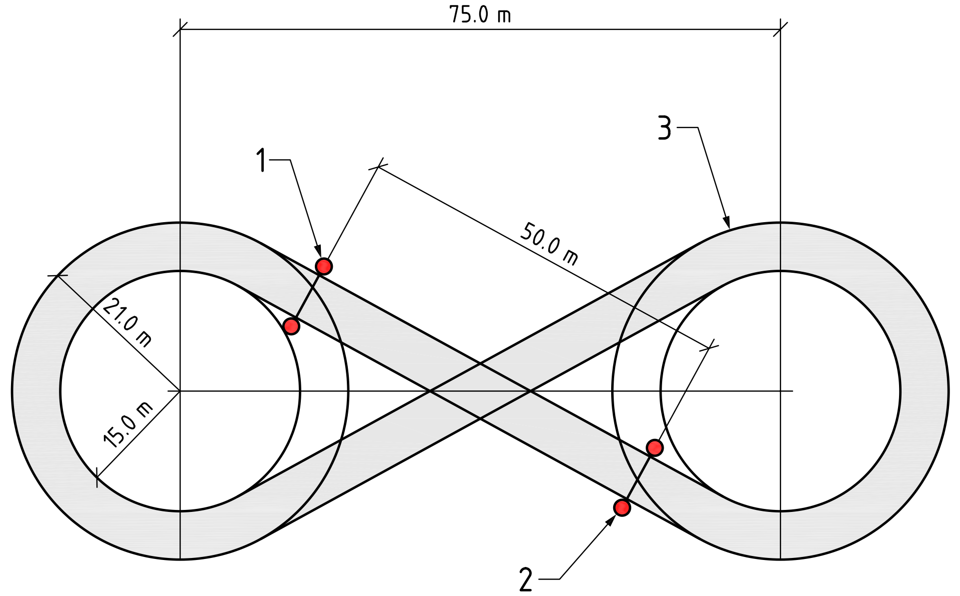
9.3.1.4 The test track surface temperature shall be (20 ±15)°C.

9.3.1.5 The track gradient in the direction of travel shall be ≤2%.

9.3.2 Manoeuvre course layout

The manoeuvre course shall be set up in accordance with Figure 4.The straight sections shall be used for acceleration and braking into the corners.

Figure 4 – Manoeuvre course



Key

1 Track markers indicating start of 50 m accelerate-stop section

2 Track markers indicating end of 50 m accelerate-stop section

3 Track markers specifying the manoeuvre course and clearly visible to test engineer(s)

9.3.3 Escape and liaison course layout

The escape and liaison course shall be set up on a straight track (or banked track that simulates similar vehicle dynamic forces experienced on a straight track). The setup shall allow the test vehicle to be driven over the distance and speed selected in accordance with Table 12.

9.4 Test vehicle preparation

9.4.1 The test vehicle operational kerb mass (**3.1.6**) shall be correctly configured.

9.4.2 The test vehicle shall be ballasted to GVM.

NOTE *The test vehicle loading should take into account the mass of the test engineer(s) and test equipment installed on the test vehicle.*

9.4.3 The test apparatus in accordance with Clause **4** shall be installed on the test vehicle to facilitate data collection in accordance with **9.5**.

NOTE 1 *The installation method may be determined by the test site provided the data collection can be completed successfully.*

NOTE 2 *The test vehicle loading should take into account the mass of the test engineer(s) and test equipment installed on the test vehicle.*

9.4.4 Using the tyre pressure gauge (**4.10**) the tyre pressures shall be checked cold and adjusted to the manufacturer's specified pressure.

9.4.5 Check the tyres, wheels and run flats and replace if damaged.

9.5 Test procedure

NOTE 1 *Testing should conform with the test site local safety procedures at all times.*

NOTE 2 *The test procedure described in **9.5** requires test vehicles to complete manoeuvres and to be driven at speeds that could be hazardous.*

NOTE 3 *For some tests, observers track side or in a chase vehicle may be used to provide additional feedback information to the test engineers conducting the tests.*

NOTE 4 *During the test a second test engineer may also occupy the test vehicle to facilitate the recording of observations.*

9.5.1 General

9.5.1.1 Prepare a test log to record data in accordance with Annex E.

9.5.1.2 Prepare the test vehicle in accordance with **9.4**

9.5.1.3 Using the infrared temperature sensor (**4.4**) measure and record the test track surface temperature and track surface condition (**3.1.12**) in accordance with **9.3.1.3** to **9.3.1.5** in the test log (see Annex E).

9.5.1.4 If at any stage during the test the tyres become unserviceable the test is stopped.

NOTE *Unserviceable is a where the run flat system has failed and it is deemed that the test cannot be continued. For example, the tyre becomes detached from the rim, or if the tyre catches fire, or the test vehicle cannot be controlled safely.*

9.5.2 Manoeuvre phase

9.5.2.1 Position the front of the test vehicle at the start of the manoeuvre course, position 1 (see Figure 4).

9.5.2.2 Deflate the specified tyre and remove the valve core and record the tyre position in the test log (see Annex E).

9.5.2.3 Start the recording system (**4.7**) and check that it is recording.

9.5.2.4 Accelerate the test vehicle forward as quickly as possible from position 1, bringing it to a halt as quickly as possible with the front of the test vehicle coming to rest at position 2 (see Figure 4).

9.5.2.5 Immediately accelerate rearwards as quickly as possible, bringing the test vehicle to a halt as quickly as possible with the front of the test vehicle coming to rest at position 1 (see Figure 4).

9.5.2.6 Immediately accelerate forward, driving the test vehicle at the fastest speed possible but staying within the specified limits (**9.3.2**) of the manoeuvre course.

9.5.2.7 When the 1 km is reached, or the test vehicle becomes unserviceable, bring the test vehicle to a halt.

9.5.2.8 Drive the test vehicle at (8 ±1) km/h and position the front of the test vehicle at the start of the manoeuvre course, position 1.

9.5.2.9 Accelerate the test vehicle forward as quickly as possible from position 1, bringing it to a halt as quickly as possible with the front of the test vehicle coming to rest at position 2 (see Figure 4).

9.5.2.10 Immediately accelerate rearwards as quickly as possible, bringing the test vehicle to a halt as quickly as possible with the front of the test vehicle coming to rest at position 1 (see Figure 4).

9.5.2.11 Stop the recording system and save the data.

9.5.2.12 Record the qualitative observations in accordance with Table 13 in the test log (see Annex E).

9.5.2.13 Visually check and record the conditions of the tyres and if serviceable proceed to the escape phase. The test vehicle is not left stationary for more than (25 ±5) s prior to moving to the next phase.

9.5.3 Escape phase

9.5.3.1 Drive the test vehicle at (20 ±5) km/h to the start of the escape course and bring the test vehicle to a halt.

9.5.3.2 Record the odometer reading and time in the test log (see Annex E).

9.5.3.3 Start the recording system (**4.7**) and check it is recording.

9.5.3.4 Accelerate the test vehicle up to the specified escape speed and maintain this speed for the specified distance.

9.5.3.5 When 3 km is reached, or the test vehicle becomes unserviceable, bring the test vehicle to a halt.

9.5.3.6 Stop the recording system and save the data.

9.5.3.7 Record the odometer reading and time in the test log (see Annex E).

9.5.3.8 Record the qualitative observations in accordance with Table 13 in the test log (see Annex E).

9.5.3.9 Visually check and record the conditions of the tyres in the test log and if serviceable proceed to the liaison phase. The test vehicle is not left stationary for more than (25 ±5) s prior to moving to the next phase.

9.5.4 Liaison phase

9.5.4.1 Drive the test vehicle at (20 ±5) km/h to the start of the liaison course and bring the test vehicle to a halt.

9.5.4.2 Record the odometer reading and time in the test log (see Annex E).

9.5.4.3 Start the recording system (**4.7**) and check it is recording.

9.5.4.4 Accelerate the test vehicle up to the specified liaison speed and maintain this speed for the specified distance.

9.5.4.5 When 100 km is reached, or the test vehicle becomes unserviceable, bring the test vehicle to a halt.

9.5.4.6 Stop the recording system and save the data.

9.5.4.7 Record the odometer reading and time in the test log (see Annex E).

9.5.4.8 Record the qualitative observations in accordance with Table 13 in the test log (see Annex E).

9.5.4.9 Visually check and record the conditions of the tyres in the test log (see Annex E).

9.5.4.10 Replace the tested wheel/tyre/run flat system with a new set.

9.5.4.11 Repeat steps **9.5.2.1** to **9.5.4.10** for the second test.

9.6 Expression of results

When the run flat test has been completed in accordance with **9.5**, score the test vehicle in accordance with the criteria given in Table 13 and record the results in the test log (see Annex E).

Table 13 – Run flat (RF) score criteria

Parameter	Score criteria			
	1	2	3	4
Traction	None/ undriveable	—	—	Good/ driveable
Stability/control	Uncontrollable	—	—	Solid/stable
Vibration and shimmy	Substantial	—	—	No vibration/shimmy
Tyre mounting	Tyre off rim	Bead detached from rim	Bead loose	Tyre normal
Tyre damage	Substantial/ Uncontrollable	—	—	No damage/ Remains controllable
Wheel rim damage	Substantial/ Uncontrollable	—	—	No damage/ Remains controllable
Smoke/fire	Heavy smoke/ flames visible	—	—	No smoke
Observed test vehicle malfunctions	High likelihood of stopping the test vehicle	—	—	Very low likelihood of stopping the test vehicle
Tyres become unserviceable	Manoeuvre or escape phase	Liaison distance (≥0 <50) km	Liaison distance (≥50 <100) km	Liaison distance ≥100 km

9.7 Report

As a minimum requirement the party completing the testing shall submit a test log and category results in accordance with Annex F.

A certificate shall be issued stating as a minimum:

a) certificate number;

b) test vehicle number/identifier (e.g. build configuration);

c) test dates and report issue date;

d) test party details (organization);

e) test apparatus details and calibration declaration;

f) test level and category;

g) test report number; and

h) statement that the test only applies to the test vehicle configuration tested.

***NOTE** In addition, supporting evidence may be included, for example photographs, video or data printouts from the recording system.*

Annex A (normative)
Payload test log

A.1 General

The payload test log and scoring is set out in Tables A.1 and A.2.

Table A.1 – Payload test log

Test ID:	Project/Test vehicle ID:	Payload test level:	Test dates:
Assessor name:			
Loading configuration:			
Tyre load rating		Wheel load rating	

Tyre pressures (bar)	TP1 (front near side)	TP2 (front off side)	TP3 (rear near side)	TP4 (rear off side)
Operational kerb mass (kg)	A (front near side)	B (front off side)	C (rear near side)	D (rear off side)

Specified payload (kg)	M1	M2	M3	M4	M5					

Operational mass (kg)	E (front near side)	F (front off side)	G (rear near side)	H (rear off side)

Manufacturer maximum front axle mass (kg) P1	Manufacturer maximum rear axle mass (kg) P2	Manufacturer gross vehicle mass (kg) GVM
Operational kerb mass front axle (kg) *K1 = A + B*	Operational kerb mass rear axle (kg) *K2 = C + D*	Total operational kerb mass (kg) *K = K1 + K2*
Operational mass front axle (kg) *O1 = E + F*	Operational mass rear axle (kg) *O2 = G + H*	Total operational mass (kg) *OM = O1 + O2*

Operational payload available (kg) *PA = GVM - K*	Operational payload required (kg) *P = M1 + M2 + M3 + M4 + M5.....Mi*

NOTE 1 Depending on the test vehicle type the operational payload is configured with simulated masses at the passenger and luggage or equipment positions.

NOTE 2 For test vehicles with more than two axles, the table should be modified to reflect the additional data and similar calculations should be completed.

Table A.2 – Payload test results

Test ID:	Project/Test vehicle ID:	Payload test level:	Test dates:
Parameter	**Score criteria**		**Results**
	Pass	**Fail**	**Pass/Fail**
Tyre load rating	operational mass at each wheel station ≤ recorded rating	operational mass at each wheel station > recorded rating	
Wheel load rating	operational mass at each wheel station ≤ recorded rating	operational mass at each wheel station > recorded rating	
GVM (kg)	GVM≥OM	GVM<OM	
Axle 1 mass (front) (kg)	P1≥O1	P1<O1	
Axle 2 mass (rear) (kg)	P2≥O2	P2<O2	
Payload (kg)	PA≥P	PA<P	
NOTE *The results only apply to the design submitted as the test vehicle. If at any stage changes are made to the design, then the results become void until the design changes are submitted for testing.*			

Annex B (normative)
Acceleration, maximum speed, through gear acceleration test log

B.1 General

The acceleration, maximum speed and through gear acceleration test log and assessment is set out in Tables B.1 and B.2.

Table B.1 – Acceleration, maximum speed, through gear acceleration performance test log

Test ID	Project/Test vehicle ID	AST test level:	Test dates:
Ambient temperature (°C):	Humidity %:	Assessor:	
Track surface condition: (dry / damp / wet / flooded) Test track surface temperature (°C):	Wind speed (km/h): Prevailing wind direction hitting: (front / rear / offside / nearside)		
Tyre maximum speed rating:	Vehicle electronic maximum speed limit value (if pre-configured):		
Test vehicle configurable settings (including any ancillary equipment):			
Speed offset			
Recording system speed km/h	Test vehicle speed indicator offset km/h		
50			
80			
110			
2wd/4wd/Automatically selected:	Gear at steady state:		

Table B.1 – Acceleration, maximum speed, through gear acceleration performance test log *(continued)*

Parameter	Specified test limit		Test 1	Test 2	Test 3	Average result
	Lower limit:	Upper limit:				
Acceleration standing start (0 – 95) km/h Time (s)						
Acceleration standing start 400 m Time (s)						
Maximum speed (km/h)						
Through gear acceleration (50 – 110) km/h Time (s)						
Through gear acceleration (80 – 110) km/h Time (s)						
Through gear acceleration (110 – 160) km/h Time (s)						

NOTE 1 *Prevailing wind direction is the direction the wind is coming from and hitting the test vehicle.*

NOTE 2 *Track surface conditions* ***(3.1.12):***

dry, the surface is not affected by water, slush, snow or ice;
damp, the surface shows a change in colour due to moisture;
wet, the surface is soaked but no significant patches of standing water are visible;
flooded, standing water patches (covering >25% of surface) are visible.

Table B.2 – Acceleration, maximum speed, through gear acceleration test results

Project/Test vehicle ID:	AST test level:	Test dates:	
Parameter	**Score criteria**		**Results**
	Pass	**Fail**	**Pass/Fail**
Acceleration standing start (0 – 95) km/h Time (s)	Recorded average test time within specified band OR Recorded average test time < specified band	Recorded average test time > specified band	
Acceleration standing start 400 m Time (s)	Recorded average test time within specified band OR Recorded average test time < specified band	Recorded average test time > specified band	
Maximum speed (km/h)	Recorded average test time within specified band	Recorded average test time > specified band OR Recorded average test time < specified band	
Through gear acceleration (50 – 110) km/h Time (s)	Recorded average test time within specified band OR Recorded average test time < specified band	Recorded average test time > specified band	
Through gear acceleration (80 – 110) km/h Time (s)	Recorded average test time within specified band OR Recorded average test time < specified band	Recorded average test time > specified band	
Through gear acceleration (100 – 160) km/h Time (s)	Recorded average test time within specified band OR Recorded average test time < specified band	Recorded average test time > specified band	
Tyre maximum speed rating	Recorded maximum average speed ≤ tyre maximum speed rating	Recorded maximum average speed > tyre maximum speed rating	
Electronic maximum speed limit	Recorded maximum average speed ≤ electronic maximum speed limit	Recorded maximum average speed > electronic maximum speed limit	

Annex C (normative) Handling test log

C.1 General

The handling test log and final assessment is set out in Tables C.1 to C.4.

Table C.1 – Handling test log

<table>
<tr><td>Test ID:</td><td>Project/Test vehicle ID:</td><td>Handling test level:</td><td>Test dates:</td></tr>
<tr><td>Temperature (°C):</td><td>Humidity %:</td><td colspan="2">Assessor:</td></tr>
<tr><td colspan="2">Track surface condition:
(dry / damp / wet / flooded)
Test track surface temperature (°C):</td><td colspan="2">Wind speed (km/h):
Prevailing wind direction hitting:
(front / rear / offside / nearside)</td></tr>
<tr><td colspan="4">Track course layout</td></tr>
<tr><td colspan="4">NOTE 1 Prevailing wind direction is the direction the wind is coming from and hitting the test vehicle.
NOTE 2 Track surface conditions (3.1.12):
dry, the surface is not affected by water, slush, snow or ice;
damp, the surface shows a change in colour due to moisture;
wet, the surface is soaked but no significant patches of standing water are visible;
flooded, standing water patches (covering >25% of surface) are visible.</td></tr>
</table>

Test vehicle configurable settings (including any ancillary equipment):

Track course test data	
Test	**Test time (s)**
1	
2	
3	
4	
5*	
6*	
7*	
8*	
9*	
10*	
*Test vehicle is on limit of control	

Slalom course test data	
Test	**Test time (s)**
1	
2	
3	
4	
5	
6	
Avg*	
*Average of the 3 fastest times	

Lane change course test data			
Test	**Entry speed km/h**	**Exit speed km/h**	**Test speed km/h**
1			
2			
3			
4			
5			
6			
Avg*			
*Average the 3 fastest test speeds. The spread of the 3 test speeds is ±3 km/h			

J turn course test data	
Test*	
1	
2	
3	
4	
5	
6	
*At least 3 test times shall be recorded. The spread of the three times shall be ±3 m/s	

Table C.2 – Track test results

Test ID:		Project/Test vehicle ID:			Test dates:
Parameter	**Score criteria**				**Results**
	1	**2**	**3**	**4**	**Score**
Handling balance	Requires constant adjustment, unpredictable, hard work			Predictable, consistent, easy and safe	
Grip level	Relatively slow corner speeds and long braking distances			Highly capable for its class	
Braking response	Significant steering correction required			No path deviation	
Power change response	Difficult to balance mid-corner and control exit acceleration			Useful mid-corner control and stable exit acceleration	
Turn-in response	Unpredictably strong or weak, non-linear or slow to respond			Swift and proportional response	
Roll control	Undue risk of rollover or perception of instability			Low, swiftly adopted roll angle and no control or stability issues	
Pitch control	Excessive pitch angle causing discomfort			Low, swiftly adopted pitch angle	
Straight line stability	Significant steering corrections required			No steering corrections required	
Steering effort level	Difficult to drive at speed, possesses catch-up			Easy to control at speed	
Steering feel	No sense of cornering speed, undue vibrations or excess friction			Perfectly indicates cornering speed and the limit of handling	
ESC and TC system performance	Early, excessive and aggressive intervention			No hinderance to rapid progress, whilst activating appropriately	
Driver controls ergonomics	Awkward to use, mismatched effort levels			Easy operation with informative effort levels	
				Total score	

Table C.3 – Slalom test results

Test ID:	Project/Test vehicle ID:		Test Level:	Test dates:
Parameter	**Score criteria**			**Results**
	Pass	**Fail**		**Pass/Fail**
Average time to complete slalom (s)	Recorded test time within specified band OR Recorded test time < specified band	Recorded test time > specified band		

Table C.4 – Lane change test results

Test ID:	Project/Test vehicle ID:		Test Level:	Test dates:
Parameter	**Score criteria**			**Results**
	Pass	**Fail**		**Pass/Fail**
Average speed to complete lane change (km/h)	Recorded test speed within specified band OR Recorded test speed < specified band	Recorded test speed > specified band		

Table C.5 – J turn test results

Test ID:		Project/Test vehicle ID:		Test dates:	Test dates:
Parameter	**Score criteria**			**Results**	**Results**
	1	**2**	**3**	**4**	**Score**
Reverse steering response	Unpredictably strong or weak, slow to respond, difficult to control			Swift and proportional response, easy to control	
Roll control	Undue risk of rollover or perception of instability			Low, swiftly adopted roll angle and no control or stability issues	
Steering effort level	Difficult to drive at speed, possesses catch-up			Easy to control at speed	
Steering feel	No sense of cornering speed, undue vibrations or excess friction			Perfectly indicates cornering speed and the limit of handling	
ESC and TC system performance	Early, excessive and aggressive intervention			No hinderance to rapid progress	
Driver controls ergonomics	Awkward to use, mismatched effort levels			Easy operation with informative effort levels	
				Total score	

Annex D (normative)
Brake test log

D.1 General

The brake test log and final assessment is set out in Tables D.1 and D.2.

Table D.1 – Brake test log

Test ID:	Project/Test vehicle ID:	Test dates:
Temperature (°C):	Humidity %:	Assessor:
Track surface condition: (dry / damp / wet / flooded) Test track surface temperature (°C):	Wind speed: Prevailing wind direction hitting: (front / rear / offside / nearside)	
Brake cold performance test procedure	V_{max} OR 100 km/h *(whichever is lower)*	
	Brake pedal force (cold)	
	d_m (cold)	
	stopping distance	
Brake heating test procedure	V1	
Brake hot performance test procedure	V_{max} OR 100 km/h *(whichever is lower)*	
	d_m (hot)	
Brake recovery test procedure	V_{max} OR 50 km/h *(whichever is lower)*	
Brake recovery performance test procedure	V_{max} OR 100 km/h *(whichever is lower)*	
	d_m (recovery)	
NOTE 1 *V1 = 0.8*V_{max}. If 0.8*V_{max} is less than 80 km/h then the test speed is the lower of V_{max} or 80 km/h. If 0.8* V_{max} exceeds 120 km/h, the test speed is 120 km/h.* ***NOTE 2*** *V_{max} = maximum vehicle speed*		

Table D.2 – Brake test results

Braking test results					
Test ID:	Project/Test vehicle ID:			BK test level:	
Test dates:					
Parameter	**Score criteria**				
	1	**2**	**3**	**4**	**Score**
Brake test					
Brake cold performance	$d_m < 5$ m/s^2 or stopping distance $> 0.15V_1 + V_1^2/130$	—	—	$d_m \geq 5$ m/s^2 AND stopping distance $\leq 0.15V_1 + V_1^2/130$	
Brake hot performance	d_m (hot) < 4 m/s^2 or d_m (hot)< 0.6 × d_m (cold)	d_m (Hot)≥ 0.6*d_m (cold) and <0.7*d_m (cold)	d_m (hot) ≥ 0.7*d_m (cold) and < 0.8 × d_m (cold)	d_m (hot)> 0.9 × d_m (cold)	
Brake recovery performance	d_m (recovery) ≤ 0.7*d_m (cold) OR >1.5*d_m (cold)	—	—	d_m (recovery) > 0.7*d_m (cold) AND ≤1.5*d_m (cold)	
Smoke/fire [A)]	Visible flames	—	—	No visible flames	
Heat damage [B)]	Severe heat damage to caliper dust seals, neighbouring rubber components, ball joint boot, ABS wiring harness, pad-wear sensors	Minor heat damage to caliper dust seals, neighbouring rubber components, ball joint boot, ABS wiring harness, pad-wear sensors	Scorch/singe damage to caliper dust seals, neighbouring rubber components, ball joint boot, ABS wiring harness, pad-wear sensors	No heat damage to caliper dust seals, neighbouring rubber components, ball joint boot, ABS wiring harness, pad-wear sensors	

Table D.2 – Brake test results *(continued)*

Brake pad detachment/ delamination [B)]	Complete delamination or separation of the pad material from the back plate	Minor delamination of pad material, or separation from the back plate. Minor central cracks across the pad material are acceptable	Cracking of pad material around the backplate. Minor central cracks across the pad material are acceptable	No delamination or separation of pad material. Minor central cracks across the pad material are acceptable	
Front brake degradation [B)]	Substantial crumbling and cracking to pad material	Moderate crumbling and cracking to pad material	Minor crumbling and cracking to pad material	No crumbling and cracking to pad material	
Rear brake degradation [B)]	Substantial crumbling and cracking to pad material	Moderate crumbling and cracking to pad material	Minor crumbling and cracking to pad material	No crumbling and cracking to pad material	
Vibration through steering wheel [A)]	Substantial vibration, where the vehicle is uncontrollable	Moderate	Minor	No significant change in vibration	
				Total score	

NOTE *d_m = mean fully developed longitudinal acceleration calculated in accordance with* **8.1**.
A) Qualitative assessment criteria used during brake heating test procedure and brake recovery test procedure
B) requires disassembling of front and rear brake assemblies for inspection test procedure.

Annex E (normative)
Run flat test log

E.1 General

The run flat test log and final assessment is set out in Tables E.1 and E.2.

Table E.1 – Run flat test log

<table>
<tr><td colspan="2">Test ID:</td><td colspan="4">Project/Test vehicle ID:</td><td colspan="5">RF test level:</td><td colspan="1">Test dates:</td></tr>
<tr><td colspan="3">Temperature (°C):</td><td colspan="5">Humidity %:</td><td colspan="4">Assessor:</td></tr>
<tr><td colspan="5">Track surface condition:
(dry / damp / wet / flooded)
Test track surface temperature (°C):</td><td colspan="7">Wind speed (km/h):
Prevailing wind direction hitting:
(front / rear / offside / nearside)</td></tr>
<tr><td colspan="12">Deflated tyre position:</td></tr>
<tr><td colspan="12">Manoeuvre phase</td></tr>
<tr><td colspan="1">Tyre conditions (visual inspection)</td><td colspan="3">Front near side:</td><td colspan="3">Front off side:</td><td colspan="3">Rear near side:</td><td colspan="2">Rear off side:</td></tr>
<tr><td colspan="6"></td><td colspan="3">Distance
km</td><td colspan="1">Time
h</td><td colspan="2">Average speed
km/h</td></tr>
<tr><td colspan="6">1st Accel+ brake action, pre-manoeuvre phase</td><td colspan="3"></td><td colspan="1"></td><td colspan="2"></td></tr>
<tr><td colspan="6">Manoeuvre phase</td><td colspan="3"></td><td colspan="1"></td><td colspan="2"></td></tr>
<tr><td colspan="6">2nd Accel+brake action, post-manoeuvre phase</td><td colspan="3"></td><td colspan="1"></td><td colspan="2"></td></tr>
<tr><td colspan="1">Tyre conditions (visual inspection)</td><td colspan="3">Front near side:</td><td colspan="3">Front off side:</td><td colspan="3">Rear near side:</td><td colspan="2">Rear off side:</td></tr>
<tr><td colspan="12">Escape phase</td></tr>
<tr><td colspan="1">Odometer/ time (start)</td><td colspan="5">Odometer/time (finish)</td><td colspan="3">Distance
km</td><td colspan="1">Time
h</td><td colspan="2">Average speed
km/h</td></tr>
<tr><td colspan="1"></td><td colspan="5"></td><td colspan="3"></td><td colspan="1"></td><td colspan="2"></td></tr>
</table>

Table E.1 – Run flat test log *(continued)*

<table>
<tr><td>Tyre conditions (visual inspection)</td><td>Front near side:</td><td colspan="2">Front off side:</td><td colspan="2">Rear near side:</td><td>Rear off side:</td></tr>
<tr><td colspan="7">Liaison phase</td></tr>
<tr><td>Odometer/ time (start)</td><td colspan="2">Odometer/time (finish)</td><td colspan="2">Distance
km</td><td>Time
h</td><td>Average speed
km/h</td></tr>
<tr><td></td><td colspan="2"></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td>Tyre conditions (°C):</td><td>Front near side:</td><td colspan="2">Front off side:</td><td colspan="2">Rear near side:</td><td>Rear off side:</td></tr>
</table>

Table E.2 – Run flat test results

Test ID:	Project/Test vehicle ID:	RF test Level:	Test dates:

Parameter	Score criteria				
	1	2	3	4	Score
Traction	None/ undriveable			Good/ driveable	
Stability/control	Uncontrollable			Solid/stable	
Vibration and shimmy	Substantial			No vibration/ shimmy	
Tyre mounting	Tyre off rim	Bead detached from rim	Bead loose	Tyre normal	
Tyre damage	Substantial Uncontrollable			No damage Remains controllable	
Wheel rim damage	Substantial Uncontrollable			No damage Remains controllable	
Smoke/fire	Heavy smoke/ flames visible			No smoke	
Observed test vehicle malfunctions	High likelihood of stopping the test vehicle			Very low Likelihood of stopping the test vehicle	
Tyres become unserviceable	Manoeuvre or escape phase	Liaison distance (≥0 <50) km	Liaison distance (≥50 <100) km	Liaison distance ≥100 km	
				Total score	

Bibliography

Other publications

[1] VEHICLE SECURITY ADVISORY GROUP. *VSAG 12 Part 3, Civilian armoured vehicles – Automotive testing handbook*. London: VSAG: 2012.

[2] VEHICLE CERTIFICATION AGENCY. *European Community Whole Vehicle Type Approval (EC-WVTA).* Available from: http://www.dft.gov.uk/vca/vehicletype/ecwvta-framework-directive.asp [viewed April 2017].

[3] DRIVER AND VEHICLE STANDARDS AGENCY. *Individual Vehicle Approval (IVA).* Available from: https://www.gov.uk/vehicle-approval/individual-vehicle-approval [viewed April 2017].

[4] DRIVER AND VEHICLE STANDARDS AGENCY. *Consolidated code of practice: enforcement weighting of vehicles*. Available from: www.gov.uk/government/publications/weighing-vehicles-for-enforcement-consolidated-code-of-practice. [viewed April 2017].

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ISBN 978-0-580-91487-4