



Vehicle Standard (Australian Design Rule 35/05 – Commercial Vehicle Brake Systems) 2013

I, JAMIE EDWARD BRIGGS, Assistant Minister for Infrastructure and Regional Development, determine this vehicle standard under section 7 of the *Motor Vehicle Standards Act 1989*.

Dated 22 October 2013

[Signed]

JAMIE EDWARD BRIGGS

Assistant Minister for Infrastructure and Regional Development

CONTENTS

0.	LEGISLATIVE PROVISIONS.....	3
1.	SCOPE.....	3
2.	APPLICABILITY	3
3.	DEFINITIONS	5
4.	DESIGN REQUIREMENTS	5
5.	PERFORMANCE REQUIREMENTS.....	16
6.	GENERAL TEST CONDITIONS	16
7.	PARTICULAR TEST CONDITIONS.....	19
8.	ALTERNATIVE STANDARDS	24
	APPENDIX 1	32
	APPENDIX 2	35

0. LEGISLATIVE PROVISIONS**0.1. NAME OF STANDARD**

0.1.1. This standard is the Vehicle Standard (Australian Design Rule 35/05 – Commercial Vehicle Brake Systems) 2013.

0.1.2. This standard may also be cited as Australian Design Rule 35/05 — Commercial Vehicle Brake Systems.

0.2. COMMENCEMENT

0.2.1. This standard commences on the day after it is registered.

1. SCOPE

This standard prescribes the requirements for brakes on commercial motor vehicles and large passenger vehicles to ensure safe braking under normal and emergency conditions.

2. APPLICABILITY AND IMPLEMENTATION

This standard applies to the design and construction of vehicles from the dates set out in clauses 2.1, 2.2, 2.3 and the table below.

2.1. 1 November 2015 on all new model vehicles.

2.2. 1 November 2016 on all vehicles of category MB or MC.

2.3. 1 November 2017 on all vehicles of category LEG, MD, ME, NA, NB or NC.

2.4. For the purposes of clause 2.1 a "new model" is a vehicle model first produced with a '*Date of manufacture*' on or after the agreed date in clause 2.1.

2.5. Vehicles of category MB, MC or NA complying with the requirements of ADR 31/... will be accepted as complying with this standard.

2.6. Vehicles of category LEG that are fitted with a single foot pedal controlling both front and rear service brakes must comply with this standard. Other LEG vehicles must comply with ADR 33/...

2.7. This standard does not apply to combinations of drawing vehicle and trailer.

2.8. A vehicle comprising 2 or more non-separable articulated units must be considered as a single vehicle for the purposes of this standard.

Applicability Table

Vehicle Category	ADR Category Code *	UNECE Category Code *	Manufactured on or After	Acceptable Prior Rules
Moped 2 wheels	LA	L1	not applicable	
Moped 3 wheels	LB	L2	not applicable	
Motor cycle	LC	L3	not applicable	
Motor cycle and sidecar	LD	L4	not applicable	
Motor tricycle	LE	L5		
	LEM		not applicable	
	LEP		not applicable	
	LEG		1 November 2015**	/02, /03, /04
Passenger car	MA	M1	not applicable	
Forward-control passenger vehicle	MB	M1	1 November 2015**	Nil
Off-road passenger vehicle	MC	M1	1 November 2015**	Nil
Light omnibus	MD	M2	1 November 2015**	
up to 3.5 tonnes 'GVM' and up to 12 seats	MD1		1 November 2015**	/02, /03, /04
up to 3.5 tonnes 'GVM' and more than 12 seats	MD2		1 November 2015**	/02, /03, /04
over 3.5 tonnes and up to 4.5 tonnes 'GVM'	MD3		1 November 2015**	/02, /03, /04
over 4.5 tonnes and up to 5 tonnes 'GVM'	MD4		1 November 2015**	/04
Heavy omnibus	ME	M3	1 November 2015**	/04
Light goods vehicle	NA	N1	1 November 2015**	Nil
Medium goods vehicle	NB	N2	1 November 2015**	/04
over 3.5 tonnes up to 4.5 tonnes 'GVM'	NB1			
over 4.5 tonnes up to 12 tonnes 'GVM'	NB2			
Heavy goods vehicle	NC	N3	1 November 2015**	/04
Very light trailer	TA	O1	not applicable	
Light trailer	TB	O2	not applicable	
Medium trailer	TC	O3	not applicable	
Heavy trailer	TD	O4	not applicable	

** See clauses 2.1 to 2.4

* UN ECE Vehicle Categories are provided for information and as reference only. The category code may also be in the format L₁, L_A etc.

3. DEFINITIONS

- 3.1. For vehicle categories, definitions and meanings used in this standard, refer to:
- 3.2. Vehicle Standard (Australian Design Rule Definitions and Vehicle Categories) 2005; and
- 3.3. Definitions in clause 0. of Appendix 2 of this standard.

4. DESIGN REQUIREMENTS

- 4.1. *'Service Brake System'*
 - 4.1.1. The vehicle must be equipped with a *'Service Brake System'* operable on all road wheels through the medium of a single *'Control'* so placed that it can be actuated by the operator from the normal driving position.
 - 4.1.1.1. The vehicle, if category MB, MC or NA, must be equipped with an Electronic Stability Control system and a Brake Assist System, both meeting the requirements of APPENDIX 2.
 - 4.1.2. The vehicle must have one or more service brake failure *'Visible Indicators'* meeting the requirements of clause 4.2.
 - 4.1.3. Where separate methods of actuation are provided for any of the functions of the brake system, the actuation of one function must not cause the operation of another function.
 - 4.1.4. Each *'Service Brake System'* must incorporate devices which compensate for any increased movement of its components arising from wear. Such devices must themselves contain provision for securing them throughout their working range in any position to which they may be adjusted to or to which they may themselves automatically adjust.
 - 4.1.5. The vehicle, if equipped with an *'Antilock System'*, must meet the requirements of APPENDIX 1; and
 - 4.1.5.1. the vehicle, if category MD4, ME NB or NC, with not more than four axles, must be equipped with an *'Antilock System'* that meets the following requirements;
 - 4.1.5.2. A manual device may be provided to disconnect or change the control mode of the *'Antilock System'*, on vehicles of categories NB and NC; where a device is fitted to NB or NC category vehicles, the following conditions shall be met:
 - 4.1.5.2.1. The vehicle with the *'Antilock System'* disconnected or the control mode changed by the device referred to in clause 4.1.5.2 above shall satisfy all the relevant requirements in clause 7.13 of this standard;
 - 4.1.5.2.2. An optical warning signal shall inform the driver that the *'Antilock System'* has been disconnected or the control mode changed; the red or yellow *'Antilock System'* failure warning signal specified in APPENDIX 1 may be used for this purpose. The warning signal may be constant or flashing;

- 4.1.5.2.3. The *'Antilock System'* shall automatically be reconnected/returned to on-road mode when the ignition (start) device is again set to the "ON" (run) position; or for vehicles fitted with a switch to positively select all wheel drive, when all wheel drive is deselected; or for vehicles fitted with permanent all wheel drive; when any centre differential is unlocked.
- 4.1.5.2.4. The vehicle user's handbook provided by the manufacturer should warn the driver of the consequences of manual disconnection or mode change of the *'Antilock System'*;
- 4.1.5.2.5. The device referred to in clause 4.1.5.2 above may, in conjunction with the vehicle, disconnect/change the control mode of the *'Antilock System'* of a trailer. A separate device for the trailer alone is not permitted.
- 4.1.6. All components and devices in the *'Brake System'* must meet or exceed at least one appropriate and recognized international, national or association standard, where such standards exist, or the relevant parts thereof. 'Recognized' can be taken to include SA, SAE, BS, JIS, DIN, performance and design related ISO standards and UNECE standards.
- 4.1.7. Traction control systems may utilize part of the *'Service Brake System'* provided that, except for parts common to both the traction control system and the *'Service Brake System'*, the traction control system or any failure of it cannot interfere with normal braking.
- 4.1.8. Brake line couplings must not be interchangeable and must be polarized. Couplings must comply with the requirements of AS 4945-2000 Commercial road vehicles - Interchangeable quick connect/release couplings for use with air-pressure braking systems.
- 4.1.9. Where the vehicle is equipped to tow a trailer which uses air at a positive pressure, the *'Established Retardation Coefficient'* of the *'Service Brake System'* measured using the general test conditions of part 6 and the particular test conditions of clause 7.13 must be between the upper and lower boundaries of:
- 4.1.9.1. Figure 1 for each value of *'Control Signal'* used, when fully laden; and
- 4.1.9.2. For vehicles not equipped with an *'Antilock System'*, but fitted with a *'Variable Proportioning Brake System'*, Figure 2 for each value of *'Control Signal'* used, when at *'Lightly Loaded Test Mass 35%'*; and
- 4.1.9.3. For vehicles not equipped with an *'Antilock System'*, but fitted with a *'Variable Proportioning Brake System'*, progressively between Figure 2 and Figure 1 for each value of *'Control Signal'* used. *'Established Retardation Coefficients'* may be determined by calculation for intermediate states of load between *'Lightly Loaded Test Mass 35%'* and fully laden. The calculations must include not less than 5 points and include any critical point.
- 4.1.9.4. Where the vehicle is a variant of a previously tested vehicle and the effects of the changes on braking performance are known by a test conducted on a complete vehicle, a component or a sub-assembly of components, the requirements of this clause can be met by *'Approved'* calculations.

- 4.1.9.5. The requirements relating to the figures specified in clauses 4.1.9.1., 4.1.9.2. and 4.1.9.3. are valid for vehicles with only a pneumatic '*Control Line*', as well as for vehicles with an additional electric '*Control Line*'. In both cases, the reference value (abscissa of the figures) will be the value of the transmitted pressure in the '*Control Line*':
- (a) For vehicles equipped with a pneumatic '*Control Line*' only, this will be the actual pneumatic pressure in the '*Control Line*';
- (b) For vehicles equipped with an additional electric '*Control Line*', this will be the pressure corresponding to the transmitted digital demand value in the electric '*Control Line*', according to ISO 11992:2003 including ISO 11992-2:2003 and its Amd.1:2007.
- Vehicles equipped with both pneumatic and electric '*Control Lines*' shall satisfy the requirements of the figures related to both '*Control Lines*'. However, identical braking characteristic curves related to both '*Control Lines*' are not required.
- 4.1.10. Where the vehicle has a '*Rated Towing Capacity*' of more than 4.5 tonnes, either:
- 4.1.10.1. the vehicle must have certification which provides for the operation of trailer brakes using air at a positive pressure as described in clause 4.1.9 or
- 4.1.10.2. the '*Manufacturer*' must supply to the '*Administrator*' sufficient data to allow the vehicle's '*Service Brake System*' to be modelled under laden braking conditions. Provision of the data derived from the tests performed as described by clause 7.13.2 will be considered as sufficient to meet the requirements of this clause.
- 4.1.10.3. Where the vehicle is a variant of a previously tested vehicle and the effects of the changes on braking performance are known by a test conducted on a complete vehicle, a component or a sub-assembly of components, the requirements of this clause can be met by '*Approved*' calculations.
- 4.1.11. Where the '*Service Brake System*' incorporates a single '*Brake Power Unit 35/...*' an '*Audible Indicator*' must be provided which must operate at all times when the service brake failure '*Visible Indicator*' operates as specified in clause 4.2.
- 4.1.12. Each air reservoir in a compressed air '*Brake System*' must be fitted with a manual condensate drain valve at the lowest point. An automatic condensate valve may be fitted provided it also drains the lowest point. The manual drain valve may be incorporated in the automatic valve.
- 4.2. '*Visible Indicator*'
- 4.2.1. The '*Visible Indicator*' must operate whenever any of the conditions listed in clauses 4.2.2 to 4.2.4 as applicable occur while the ignition or electrical control switch is in the "engine on" position or while the engine is running.

- 4.2.2. For a '*Service Brake System*' incorporating a hydraulic brake circuit and no '*Brake Power Unit 35/...*' in that hydraulic circuit, condition A or optionally condition B must be met;

Condition A

- A.1 When a pressure failure occurs in any part of the '*Service Brake System*', except for pressure failure caused by either:
- A.1.1 a structural failure of a housing that is common to two or more sub-systems; or
- A.1.2 failure of a component of a '*Brake Power Assist Unit*'.
- A.2 In the event of such failure, the indicator operation requirement is deemed to be satisfied if the indicator operates before or upon application of:
- A.2.1 a differential line pressure of not more than 1.55 MPa between the active and failed brake systems measured either at a master cylinder outlet, or at a slave cylinder outlet if the master cylinder controls a slave cylinder at a booster unit;
- A.2.2 a '*Pedal Effort 35/...*' of 225 N in the case of unassisted '*Service Brake Systems*'; or
- A.2.3 a '*Pedal Effort 35/...*' of 115 N in the case of '*Service Brake Systems*' with a '*Brake Power Assist Unit*'.

Condition B

- B.1 When a drop in the level of brake fluid occurs in the reservoir(s), either to less than the '*Manufacturer's*' designated minimum level or to less than 25 percent of the reservoir(s) fluid capacity whichever is the greater volume.
- B.2 In the case where a master cylinder reservoir also contains fluid for the use of a system other than the brake system, the indicator system and the reservoir must be so designed that the indicator lamp will only be activated when there are variations in the fluid level in that part of the reservoir provided exclusively for the use of the brake system.
- 4.2.3. For a '*Service Brake System*' incorporating one or more '*Brake Power Units 35/...*' in any section of the '*Service Brake System*', the '*Visible Indicator*' must operate when the supply pressure in any one '*Brake Power Unit 35/...*' drops to or below 65 percent of the '*Average Operating Pressure*'.
- 4.2.4. For vehicles equipped to tow a trailer using air at positive pressure, when the pressure in the '*Supply Line 35/...*' drops to or below 450 kPa, the '*Visible Indicator*' must operate as required by clause 4.2.1.
- 4.2.4.1. The '*Visible Indicator*' may also operate when the '*Supply Line 35/...*' energy level is reduced at a rate of not less than 0.15E/sec provided that in all cases the '*Visible Indicator*' must operate as required by clause 4.2.1. when the pressure in the '*Supply Line 35/...*' drops to or below 450 kPa.

- 4.2.4.2. the *'Visible Indicator'* must not operate when a trailer is not connected and no other defect is present. The absence of a trailer may be determined by the pressure in the *'Supply Line 35/...'* dropping to or below 35 kPa.
- 4.2.5. Where the requirement of clause 4.2 necessitates the provision of more than one system failure sensor, the sensors may be interconnected to actuate only one *'Visible Indicator'*.
- 4.2.6. As a check of function, the *'Visible Indicator'* must be so designed that it operates when:
- 4.2.6.1. the ignition or electrical control switch is turned from the 'engine off' position to the 'engine on' position, and the engine is not operating, and (unless a failure exists in the brake system) it must not operate when the engine is running; or
- 4.2.6.2. the ignition or electrical control switch is in the 'engine start' position, and (unless a failure exists in the brake system) it must not operate after the return of the ignition or electrical control switch to the 'engine on' position; or
- 4.2.6.3. the ignition or electrical control switch is in a position between the 'engine on' position and the 'engine start' position, which is designated by the 'Manufacturer' as a check position, and (unless a failure exists in the brake system) it must not operate after the return of the ignition or electrical control switch to the "engine on" position; or
- 4.2.6.4. the engine start circuit is energised and (unless a failure exists in the brake system) it must not operate when the "engine start" circuit is not energised; or
- 4.2.6.5. the ignition or electrical control switch is in the "engine on" position and the *'Parking Brake System 35/..'* is engaged for vehicles where the *'Service Brake System'* failure *'Visible Indicator'* and the Parking Brake indicator lamp are combined.
- 4.2.7. For vehicles equipped with an automatic transmission, the operation as a check of indicator function is not required when the transmission control lever is in a "forward" or "reverse" drive position.
- 4.2.8. The *'Visible Indicator'* system must be so designed that once having become operative to signal a brake failure it must operate whenever the ignition or electrical control switch is in the "engine on" position and the fault remains uncorrected.
- 4.2.9. The *'Visible Indicator'* may take the form of an indicator lamp or of a mechanical signalling device.
- 4.2.10. Where an indicator lamp is used the lamp must be labelled with at least the word "BRAKE" or, the symbol for "BRAKE FAILURE" specified in International Standard ISO 2575-2000 - "Road Vehicles - Symbols for controls indicators and tell-tales" placed either directly on the lens or adjacent to it in such a way that the label is illuminated by the same light source as the lens.

- 4.2.10.1. The letters of the label must be not less than 3 mm high and must be of a contrasting colour to their background when illuminated.
- 4.2.10.2. If the label is directly on the lens the colour of either label or lens must be red and if the label is not on the lens the colour of the lens must be red.
- 4.2.10.3. An illuminated lamp may be either steady-burning or flashing.
- 4.2.11. Where a mechanical signalling device is used, it must display at least the word "BRAKE" in letters not less than 10 mm high when the signal is deployed. Letters and background must be of contrasting colours, one of which is red.
- 4.2.12. The '*Service Brake System*' failure '*Visible Indicator*' and its specified label or display must be totally located forward of a transverse vertical plane through the point representing the intersection of the steering wheel axis of rotation and the plane of the steering wheel, and totally within the space bounded by:
- 4.2.12.1. the right-hand internal side wall;
- 4.2.12.2. a vertical plane along the longitudinal centre line of the vehicle;
- 4.2.12.3. a horizontal plane through a point on the lower edge of the instrument panel; and
- 4.2.12.4. a horizontal plane 150 mm above the highest point on the windscreen glass.
- 4.3. '*Parking Brake System 35/..*'
- 4.3.1. The vehicle must be equipped with a '*Parking Brake System 35/..*' such that in the applied position retention is effected by mechanical means, and the braking effect is achieved by either:
- 4.3.1.1. the frictional force developed between two friction surfaces; or
- 4.3.1.2. the frictional force developed between two friction surfaces, together with a '*Parking Mechanism 35/...*'.
- 4.3.2. The parking brake '*Control*' must be separate from the service brake '*Control*' and incorporate a device to retain it in the "brake on" position, and it must be designed to minimise the possibility of inadvertent release of the brake. This requirement will be deemed to be satisfied if at least 2 separate and distinct movements are necessary to disengage the parking brake.
- 4.3.3. The '*Parking Brake System 35/..*' must incorporate devices which compensate for any increased movement of its components arising from wear. Such devices must themselves contain provision for securing them throughout their working range in any position to which they may be adjusted to or to which they may themselves automatically adjust.
- 4.3.4. The '*Control*' by which the '*Parking Brake System 35/..*' is actuated must be located so that it is readily accessible to the driver in the normal driving position.

- 4.3.5. On every motor vehicle equipped to tow a trailer which uses air at positive pressure the operation of the '*Parking Brake System 35/..*' must cause the pressure in the '*Supply Line 35/...*' to drop below 35 kPa.
- 4.3.6. Once the '*Supply Line 35/...*' pressure has dropped below 35 kPa in accordance with clause 4.3.5 the '*Supply Line 35/...*' must be restored to normal when the '*Parking Brake System 35/..*' is released.
- 4.3.7. An additional '*Control*' may be fitted to provide for the independent release of the trailer parking brakes. Once the '*Supply Line 35/...*' pressure has dropped below 35 kPa in accordance with clause 4.3.5 this control must restore the '*Supply Line 35/...*' to the normal condition provided that:
- 4.3.7.1. two independent actions are required:
- 4.3.7.2. the engine is running; and
- 4.3.7.3. the '*Control*' must automatically reset to provide for operation of the '*Parking Brake System 35/..*' as described in clause 4.3.5 no later than upon the next application of the '*Control*' for the '*Parking Brake System 35/...*'.
- 4.4. ***Parking Brake Indicator Lamp***
- 4.4.1. If the vehicle is not fitted with a '*Spring Brake System*' or a '*Parking Brake System 35/..*' utilizing '*Lock Actuators*', it must be provided with a lamp which indicates that the parking brake is engaged.
- 4.4.2. The lamp may be common with or distinct and separate from any '*Service Brake System*' failure '*Visible Indicator*' lamp.
- 4.4.3. In the case of a common lamp, the lamp must be labelled with the word "BRAKE"; or the symbol for "BRAKE FAILURE" - specified as Number 4.31 in the ISO document referred to in clause 4.2.10.
- 4.4.4. In the case of a distinct and separate lamp the lamp must be labelled with at least the words "PARK BRAKE" or "PARKING BRAKE"; or the symbol for "PARKING BRAKE" specified as Number 4.32 in the ISO document referred to in clause 4.2.10 placed either directly on the lens or adjacent to it in such a way that the label is illuminated by the same light source as the lens.
- 4.4.5. The letters of the label must be not less than 3 mm high and must be of contrasting colour to their background when illuminated. If the label is directly on the lens the colour of either label or lens must be red and if the label is not on the lens the colour of the lens must be red.
- 4.4.6. The parking brake indicator lamp and its specified label must be located within the space boundaries specified in clause 4.2.12.
- 4.5. ***Secondary Brake Systems***
- 4.5.1. The vehicle must be equipped with a '*Secondary Brake System*'.
- 4.5.2. Hydraulic '*Service Brake System*' must be '*Split Service Brake System*'.

- 4.5.3. If the vehicle is equipped with one or more '*Brake Power Units 35/...*' the '*Secondary Brake System*' must be capable of application through the medium of a '*Control*'.
- 4.5.4. The '*Control*' of the '*Secondary Brake System*' must be capable of releasing and applying the secondary brake after its first application. The '*Control*' must be so placed that it can be operated by the driver in the normal driving position.
- 4.5.5. A '*Secondary Brake System*' may utilise elements of the '*Service Brake System*'.
- 4.5.6. Where the '*Secondary Brake System*' is a '*Spring Brake System*':
- 4.5.6.1. in a single circuit '*Service Brake System*', the energy supply system for maintaining the secondary brake in its released position must include a '*Stored Energy*' device that does not service any other device or equipment;
- 4.5.6.2. in the event of failure of the energy supply to any one circuit of a '*Service Brake System*' employing two or more independent circuits, the energy requirements for retaining the secondary brakes in the released position must be supplied from the '*Stored Energy*' device(s) of the other circuits or optionally from an independent '*Stored Energy*' device; and
- 4.5.6.3. with the '*Stored Energy*' device charged to its '*Average Operating Pressure*' it must have sufficient capacity to permit the '*Secondary Brake System*' to be applied and released not fewer than:
- 4.5.6.3.1. Two (2) times when the brakes are adjusted so that the distance travelled by the device which directly actuates the brake shoe or pad is a maximum, or
- 4.5.6.3.2. Three (3) times when the brakes are adjusted to the '*Manufacturer*' specifications.
- 4.5.7. In a vehicle equipped with a '*Brake Power Assist Unit*' normally supplied with high pressure fluid by an engine driven pump, a back-up system must be regarded as a '*Secondary Brake System*' if the back up source of power assistance is immediately energized by a pump driven independently of the vehicle engine.
- 4.5.8. Every motor vehicle equipped to tow a trailer must be so equipped that its brake system remains operative and has the performance of the Laden Secondary Brake Test (item 7 of Table 1) in the event of the trailer becoming disconnected. This protection must be automatic.
- 4.5.8.1. Protection systems may vent the trailer '*Supply Line 35/...*' but this must not commence;
- 4.5.8.2.1. until the energy level in the '*Supply Line 35/...*' falls below 0.54 '*E*' (350 kPa) or,
- 4.5.8.2.2. if the '*Supply Line 35/...*' energy level is reducing at a rate of not less than 0.15E/sec (100 kPa/sec), until the energy level in the '*Supply Line 35/...*' falls below 0.65 '*E*' (420 kPa).

- 4.5.9. Every motor vehicle which provides its *'Secondary Braking System'* by means of a *'Split Service Brake System'* and which is equipped to tow a trailer which uses air at positive pressure, must be so equipped that the operation of the *'Secondary Brake System'* causes a control signal proportional to the degree of braking to be present in the *'Control Line 35/...'*.
- 4.5.10. An additional *'Control'* may be fitted to provide for the independent application of a trailer *'Parking Brake System 38/00'*. Operation of the *'Control'* must cause the pressure in the *'Supply Line 35/...'* to drop below 35 kPa and remain below 35 kPa independently of the motor vehicle's *'Service Brake System'*.
- 4.5.10.1. The *'Control'* which actuates this function must be located so that it is readily accessible to the driver in the normal driving position and, marked with the words *'TRAILER EMERGENCY BRAKES'* and a description of how to operate the control, e.g. *'TRAILER EMERGENCY BRAKES – PULL'*. The *'Control'* must also be marked with the words *'NOT FOR PARKING'*. The letters must be not less than 5 mm high. Letters and background must be contrasting colours, one of which is red.
- 4.6. **Special Provisions for All Vehicles with *'Hydraulic Brake Systems'***
- 4.6.1. In cases where the *'Service Brake System'* incorporates a master cylinder, each service brake sub-system serviced by the master cylinder must have either:
- 4.6.1.1. a reservoir which contains fluid exclusively for the use of that service brake sub-system; or
- 4.6.1.2. a reservoir which contains fluid for the use of 2 or more service brake sub-systems, in which case that part of the reservoir capacity provided exclusively for the use of each service brake sub-system must be not less than the volume displaced by the master cylinder piston servicing the sub-system, during a full stroke of the piston.
- 4.6.2. The capacity of each reservoir must be not less than the fluid displacement resulting when all the wheel cylinders or calliper pistons serviced by the reservoir move from a new-lining, fully-retracted position, as adjusted according to the *'Manufacturer's'* recommendations to a fully-worn, fully-applied position. For the purpose of this clause, "fully-worn, fully-applied" means that the lining is worn to whichever of the following conditions allows the greatest shoe or pad movement:
- 4.6.2.1. the limit recommended by the *'Manufacturer'*;
- 4.6.2.2. level with rivet or bolt heads on riveted or bolted linings;
- 4.6.2.3. within 3 mm of the pad mounting surface on bonded pads; or
- 4.6.2.4. within the following distance of the shoe mounting surface on bonded linings:

Nominal Bonded	Lining Thickness	Worn thickness
< 5 mm		0.8 mm
> 5 mm	< 10 mm	3 mm

> 10 mm	< 13 mm	5 mm
>13 mm	< 19 mm	6 mm
>19 mm		7 mm

- 4.6.3. Each '*Brake Power Unit 35/...*' must be provided with a reservoir of capacity not less than the total capacity of the reservoirs required under the requirements of clause 4.6.2 plus the fluid displacement necessary to charge the piston(s) or accumulator(s) provided for the purpose of storing energy.
- 4.6.4. A statement specifying the type of fluid to be used in the brake system and displaying at least the words "WARNING. Clean filler cap before removing" must be permanently affixed, stamped, engraved or embossed with letters not less than 3 mm high, either on or partially within 150 mm of one brake fluid reservoir filler plug or cap and totally within 300 mm of all reservoir filler plugs or caps. If not stamped, engraved or embossed, the lettering must be of a contrasting colour to that of the background.
- 4.7. **Special Provisions for Systems Using '*Stored Energy*' (except '*Spring Brake Systems*')**
- 4.7.1. Any '*Stored Energy*' device for the operation or to assist in the operation of the braking system, must be so protected that failure of the device generating the energy does not result in depletion of the '*Stored Energy*'.
- 4.7.2. For systems incorporating '*Brake Power Units 35/...*', the combined volume of all '*Brake Power Unit 35/...*' devices at positive pressure must be not less than 12 times the combined volume of all the service brake chambers at their maximum travel of the pistons or diaphragms.
- 4.7.3. Any device generating energy at positive pressure for a '*Brake Power Unit 35/...*' must be of sufficient capacity to increase the pressure in the '*Stored Energy*' device(s) actually fitted to the vehicle from 85 percent of the '*Average Operating Pressure*' to the '*Average Operating Pressure*' with the vehicle's engine operating at the '*Manufacturer*' recommended maximum engine speed within a time given by the expression:

$$\text{Time} = \frac{\text{Actual '*Brake Power Unit 35/...*' capacity} \times 25(\text{sec})}{\text{'*Brake Power Unit 35/...*' test capacity}}$$

- 4.7.4. In 4.7.3, '*Brake Power Unit 35/...*' test capacity is:
- 4.7.4.1. 12 times the combined volume of all the service brake chambers at their maximum travel of the pistons or diaphragms plus,
- 4.7.4.2. in the case of a motor vehicle equipped to tow a trailer which uses air at a positive pressure, an additional 1.0 litre per tonne of '*Rated Towing Capacity*' to allow for trailer service chambers.
- 4.7.4.2.1. For vehicles with a '*Gross Combination Mass*' in excess of 65 tonnes, the value of '*Rated Towing Capacity*' for the purpose of this calculation

must be as described in the definition of '*Rated Towing Capacity*' with a value of 65 tonnes used in place of the actual vehicle '*Gross Combination Mass*'.

- 4.7.5. For '*Service Brake System*' incorporating '*Brake Power Units 35/...*' and operating at positive pressure;
- 4.7.5.1. a gauge(s) must be fitted to indicate the pressure in each independent storage system. The gauge(s) must be visible to the driver when seated in the normal driving position and must be accurate to within 7 percent of the cut-out pressure of the pressure limiting device fitted to the energy source.
- 4.7.5.2. a pressure test connection complying with clause 4 of ISO Standard 3583-1984 Road vehicles – Pressure test connection for compressed – air pneumatic braking equipment, must be fitted at either the inlet to, or in the body of, the brake chamber with the slowest reaction time in each '*Axle Group*' (in respect of brake timing as specified in clause 7.17).
- 4.7.5.3. a pressure test connection complying with clause 4 of ISO Standard 3583-1984 Road vehicles – Pressure test connection for compressed – air pneumatic braking equipment, must be fitted in the body of the '*Stored Energy*' device used for the '*Service Brake System*' which is charged last.
- 4.7.6. For '*Service Brake Systems*' incorporating '*Brake Power Assist Units*' and where the Secondary Brake is not applied by the service brake '*Control*', the combined volume of all '*Stored Energy*' devices must be such that with no replenishment of '*Stored Energy*' the performance prescribed for the Laden Secondary Brake Test in clause 7.7 must be achieved:
- 4.7.6.1. where the energy source is a pump, on the eighth actuation of the service brake '*Control*', after 7 actuations with vehicle stationary, either to full stroke or to the application of a '*Pedal Effort 35/...*' not less than 685 N whichever occurs first; or
- 4.7.6.2. where the energy source is the engine of the vehicle, on the fourth actuation of the service brake '*Control*', after 3 actuations with vehicle stationary, either to full stroke or to the application of a '*Pedal Effort 35/...*' not less than 685 N, which ever occurs first..
- 4.7.7. An energy generating device producing energy at negative pressure must be capable of achieving the volume-pressure relationship required to satisfy the conditions specified in clause 4.7.6 in a time not exceeding 3 minutes with:
- 4.7.7.1. the engine operating at not greater than 65 percent of speed corresponding to either maximum power output or governed speed where the energy generating device is a vacuum pump; or
- 4.7.7.2. the engine operating at idle speed with the gear selector in “neutral” position where the engine itself is the energy generating device.
- 4.7.8. Where the device generating the energy for any number of '*Brake Power Unit 35/...*' supplies energy to other devices, the design shall be such that

all the '*Brake Power Unit 35/...*' are preferentially charged to an energy level of not less than 0.69 '*E*' (450 kPa).

- 4.7.9. In the case of '*Service Brake Systems*' incorporating '*Brake Power Unit 35/...*' the design must be such that all '*Brake Power Unit 35/...*' must preferentially service the brake system if the energy level falls below 0.69 '*E*' (450 kPa).

5. PERFORMANCE REQUIREMENTS

- 5.1. The vehicle must be capable of meeting the range of performance tests set out in the Table 1, subject to the general test conditions of part 6 and the particular test conditions of part 7.
- 5.2. The sequence of testing may be in the order set out in the Table. Where the sequence of testing is not in the order set out in the Table, the tests must be grouped as follows:-
- Items 1 & 2;
 - Items 3 - 5 inclusive;
 - Items 6 - 10 inclusive
 - Items 11, 12 and 13 may be conducted at any time.

6. GENERAL TEST CONDITIONS

- 6.1. The ambient temperature at the test site must be within the range of 0°C to 40°C.
- 6.2. The following adjustments must be checked before commencing tests, and set to vehicle '*Manufacturer's*' recommendations:
- 6.2.1. injection or ignition timing;
 - 6.2.2. engine idle speed;
 - 6.2.3. engine governed speed if adjustable governor is fitted; and
 - 6.2.4. all brake adjustments.
- 6.3. The tyres fitted to the vehicle must be of the size and type specified by the vehicle '*Manufacturer*' as original equipment for the vehicle, and must be inflated to pressures not less than those recommended by the vehicle '*Manufacturer*'.
- 6.4. The '*Friction Elements*' of the vehicle brakes must be of the make and grade specified by the vehicle '*Manufacturer*'.
- 6.5. Decelerations must be conducted on sections of a test track or roadway that meets the following requirements:
- 6.5.1. in the case of the Service Brake Fade Test, the surface must be substantially level and any effective upward average gradient between the start and end of each deceleration test section must not exceed one percent.
- The requirements of this clause are deemed to be met if it is demonstrated that over the total number of brake applications of the Service Brake Fade Test sequence of clause 7.9, the total effective

contribution to vehicle retardation of the deceleration test section's gradients is not greater than the vehicle retardation which would result from an average upward gradient of not more than one percent;

- 6.5.2. in the case of other deceleration tests, the upward gradient, if any, must not exceed one percent.
- 6.6. Except when conducting burnishing procedures, decelerations must be conducted in a direction such that the component of wind velocity opposite to the direction of travel of the vehicle does not exceed 15 km/h.
- 6.7. Where a test requires that the gear selector be in "drive" the transmission selector control must be in the control position recommended by the 'Manufacturer' as appropriate to the speed of the vehicle at the commencement of the deceleration mode.
- 6.8. If the vehicle is not capable of attaining the initial speed requirement specified for a particular deceleration test, then, unless otherwise specified, the initial speed must be within 10 km/h of the '*Maximum Laden Vehicle Speed*'. The '*Average Deceleration*' so required must be determined from the expressions:

$$a = \frac{u^2}{2s}$$

and

$$S = K_1(0.15V + \frac{V^2}{K_2})$$

where:

S = '*Stopping Distance*', in metres

V = initial speed, in km/h

K₁, K₂ = constants, dependent on test and category, (see Table 3)

u = initial speed, in m/s

a = '*Average Deceleration*', in m/s²

- 6.9. For all effectiveness, secondary brake and partial failure tests, all parts of the vehicle must remain inside a straight lane not exceeding 3.7 metres in width, the vehicle being positioned at the approximate centre of the lane at the commencement of the deceleration.
- 6.10. Except in the case of the Parking Brake Test, each test procedure may be preceded by a series of stops or decelerations, provided the temperature measured at the surface of the disc or drum does not exceed 100°C immediately prior to the commencement of the test required by Table 1.
- 6.11. Except as permitted by clause 7.2 brakes must not be adjusted during testing. Automatic brake adjusters, if fitted, may be rendered inoperative prior to commencement of the optional Service Brake Burnishing

- Procedure. In cases where this option is exercised, adjusters must remain inoperative for the duration of the test program.
- 6.12. Except where clause 6.8 applies, any vehicle speed must not be below that specified by more than 1 km/h.
- 6.13. Where an '*Antilock System*' is fitted, it must be engaged throughout all tests except the partial failure tests where a failure in the '*Antilock System*' is simulated.
- 6.13.1. Additional tests may be optionally conducted with the '*Antilock System*' disengaged to demonstrate that the vehicle meets the performance requirements of all tests specified in part 7 when a failure in the '*Antilock System*' is simulated.
- 6.14. Where a '*Retractable Axle*' is fitted, a vehicle has a number of '*Configurations*'. It must be demonstrated that in each '*Configuration*', the vehicle complies with the laden condition requirements of this Rule for that '*Configuration*'. The laden condition for a '*Configuration*' with the '*Axle*' retracted must be considered to be when the '*Axle Group*' is laden to the '*Prescribed Transition Mass*' for the '*Configuration*' being considered. As the vehicle must automatically change its '*Configuration*' at the '*Prescribed Transition Mass*' by lowering an '*Axle*', for the purposes of demonstrating compliance with the requirements of this clause, the automatic system for lowering the '*Axle*' may be defeated.
- 6.14.1. The requirements of clause 6.14 do not apply to;
- 6.14.1.1. the '*Service Brake System*' compatibility requirements for vehicles capable of drawing a trailer as described in clause 4.1.9. For vehicles not fitted with a '*Variable Proportioning Brake System*', this requirement need only be demonstrated in the '*Configuration*' with all '*Axles*' in the '*Fully Down*' position and in the maximum laden condition as specified in clause 7.13; or
- 6.14.1.2. the Service Brake Actuation Time Test as described in clause 7.12.
- 6.14.2. It must be demonstrated that in each '*Configuration*', including with the '*Retractable Axle*' manually lowered if the manual '*Control*' for lowering of '*Retractable Axle*' is fitted, the vehicle complies with the requirements of this rule in the lightly laden condition.
- 6.15. In the case of a '*Prime Mover*', any test required to be performed with the vehicle fully laden, may be performed while towing an unbraked '*Semi-trailer*' loaded such that the required mass and mass distribution of the '*Prime Mover*' is achieved.
- 6.15.1. Allowance must be made for the effect of the increased rolling resistance resulting from the combination of vehicles being used to carry out the tests.

7. PARTICULAR TEST CONDITIONS

7.1. Pre-test Instrumentation Check

- 7.1.1. The number of decelerations for the purpose of instrumentation checks must not exceed 20.
- 7.1.2. Such decelerations must be conducted from a speed of not more than 40 km/h and any instantaneous deceleration must not exceed 3 m/s^2 .

7.2. Service Brake Burnishing Procedure

- 7.2.1. Burnishing, if conducted, consists of any desired number of decelerations to the '*Manufacturer's*' recommendation.
- 7.2.2. On completion of the burnishing procedure, if conducted, the brake system may be adjusted in accordance with the '*Manufacturer's*' recommendation.

7.3. Service Brake Lightly Laden Effectiveness Test

A series of tests must be conducted in the manner described in Table 1 (Item 3). The vehicle will be deemed to satisfy the requirements of this test, if all the parameters specified are met on at least one test within a number of tests that must not exceed 6.

7.4. Lightly Laden Secondary Brake Test

- 7.4.1. Where the secondary brake is not applied by the service brake '*Control*', the vehicle must be decelerated using only the '*Secondary Brake System*' and deemed to satisfy the requirements of this test, if all the parameters specified in Table 1 (Item 4) are met in at least one test within a number of tests that must not exceed 6.
- 7.4.2. Where the secondary brake is applied by the service brake '*Control*', the vehicle must be deemed to satisfy the requirements of this test if all the parameters specified in Table 1 (Item 4) are met in at least one test within a number of tests that must not exceed 6 for each single failure of a fluid system, including where appropriate:
 - 7.4.2.1. each sub-system of a '*Split Service Brake System*'; and
 - 7.4.2.2. failure of energy assistance in a '*Brake Power Assist Unit*'

7.5. Lightly Laden Partial Failure Test .

- 7.5.1. The requirements of this clause only applies to a vehicle fitted with a brake system where the secondary brake is applied by the service brake '*Control*'. The vehicle will be deemed to satisfy the requirements of this test if all the parameters specified in Table 1 (Item 5) are met in at least one deceleration mode within a number of deceleration modes which must not exceed 6 for each single type of partial failure, including:
 - 7.5.1.1. inoperative '*Antilock System*'; and
 - 7.5.1.2. inoperative '*Variable Proportioning Brake System*'.
- 7.5.2. One single failure must be induced prior to each set of deceleration modes and the vehicle must be restored at the completion of each set.

7.6. Service Brake Laden Effectiveness Test

A series of tests must be conducted in the manner described in Table 1 (Item 6). The vehicle will be deemed to satisfy the requirements of this test, if all the parameters specified are met on at least one test within a number of tests that must not exceed 6.

7.7. Laden Secondary Brake Test

The test procedure and determination of compliance must be as specified in clause 7.4, except that the vehicle must be at '*Maximum Loaded Test Mass 35/...*' and the test parameters to be achieved are as described in Table 1 (Item 7).

7.8. Laden Partial Failure Test

The test procedure and determination of compliance must be as specified in clause 7.5, except that the vehicle must be at '*Maximum Loaded Test Mass 35/...*' and the test parameters to be achieved are as described in Table 1 (Item 8).

7.9. Service Brake Fade Test

7.9.1. In the case of vehicles in categories MB, MC, MD and NA, 15 successive deceleration tests must be conducted at intervals no greater than 55 seconds apart, such that for an initial speed V_1 and a final speed V_2 (km/h)

$$(V_1^2 - V_2^2) > 7,500.$$

7.9.2. In the case of vehicles in categories ME, NB and NC, 20 successive deceleration tests must be conducted each not more than 70 seconds after the preceding one and with the total of 20 applications completed within 20 minutes, such that for an initial speed V_1 and a final speed V_2 (km/h)

$$(V_1^2 - V_2^2) \geq 2,700.$$

7.9.3. The initial speed must be maintained for at least 10 seconds prior to each deceleration.

7.9.4. If the vehicle is not capable of attaining the initial speed required by clause 7.9.1. or clause 7.9.2, then the speed employed in each mode for the initial speed must be not less than 80 percent of the '*Maximum Laden Vehicle Speed*' and the final speed must not be greater than half the initial speed.

7.9.5. During all deceleration modes the lowest numerical overall drive ratios as specified in clause 6.7 must be continuously engaged. Deceleration modes must be conducted from the initial speed to the final speed.

7.9.6. During acceleration periods the drive train must be employed to regain the initial speed in the shortest possible time.

7.9.7. Notwithstanding the foregoing requirements, changes of vehicle direction essential to testing and negotiation of curved sections of track may be undertaken at constant vehicle speed.

7.9.8. If the vehicle's performance characteristics are such as to preclude it from maintaining the specified maximum interval between successive

brake applications, the time interval may be increased to the minimum time required by the vehicle to achieve the specified initial speed and to maintain it for 10 seconds before each successive deceleration mode.

7.9.9. Vehicles must attain a sustained deceleration of not less than 3 m/s^2 during the first deceleration mode. Subsequent deceleration must be conducted employing a 'Control' force not less than that established during the first deceleration mode without regard to the actual deceleration achieved.

7.9.10. The Service Brake Fade Test must be followed immediately by the Service Brake Fade Effectiveness Check.

7.10. **Service Brake Fade Effectiveness Check**

The vehicle must be accelerated over a distance not exceeding 1.6 km from the final speed attained at the conclusion of the deceleration mode of the Service Brake Fade Test to the initial speed specified in Table 1 (Item 10) and the test carried out in accordance with that Item. The vehicle must be deemed to satisfy the requirements of this test if the deceleration achieved is not less than that specified in Table 1 (Item 10).

7.11. **Parking Brake Test**

7.11.1. This test must be conducted on a gradient of at least 18 percent, where the vertical rise is expressed as a percentage of the horizontal distance travelled to achieve this rise. The vehicle must be positioned on the gradient such that its longitudinal axis is parallel to the direction of the gradient. The '*Parking Mechanism 35/...*' (if fitted) must be disengaged. The service brake must be applied, transmission disengaged, and parking brake must be applied by a single application of the force specified, except that a series of applications to achieve the specified force may be made in the case of a parking brake design that does not allow the application of the specified force in a single application. The service brake must be released, for a period of not less than 5 minutes. The vehicle must then be parked in the reverse position on the gradient for not less than 5 minutes with the vehicle in condition described above.

7.11.2. The vehicle is deemed to pass this test if:

7.11.2.1. for each of the 5 minute periods it remains stationary on the gradient; and

7.11.2.2. the force required to actuate the parking brake does not exceed 685 N in the case of a foot-operated parking brake, and does not exceed 590 N applied at the centre of the handgrip, or not closer than 35 mm from the free end of the actuation lever, in the case of a hand-operated parking brake.

7.11.3. If the vehicle does not remain stationary re-application of the service brake to hold the vehicle stationary, with re-application of the specified force to the parking brake 'Control' (without release of the ratcheting or other holding mechanism of the parking brake) may be used twice to attain a stationary position.

- 7.11.4. In cases where the '*Parking Brake System 35/..*' does not utilise the service brake '*Friction Elements*', the '*Friction Elements*' of the system may be burnished to the vehicle '*Manufacturer's*' recommendation prior to the test.
- 7.12. **Service Brake Actuation Time Test**
- 7.12.1. For vehicles using air at positive pressure as the operating fluid and incorporating one or more '*Brake Power Units 35/..*'.
- 7.12.2. The test must be conducted while the vehicle is stationary.
- 7.12.2.1. Where a vehicle is fitted with a '*Variable Proportioning Brake System*' the test must be conducted with the '*Variable Proportioning Brake System*' set at the mass specified in clause 4.1.9.1.
- 7.12.3. Before commencing the test the '*Stored Energy*' device(s) must be charged to not more than the '*Average Operating Pressure*' and the brakes must be adjusted according to the '*Manufacturer's*' specifications for normal use.
- 7.12.4. The service brake '*Control*' must be operated through a full working stroke by an operator seated in the normal driving position.
- 7.12.5. The pressure at the slowest reacting brake chamber must attain a level not less than 65 percent of the '*Average Operating Pressure*' within a period not exceeding 600 milliseconds measured from the instant the '*Control*' leaves the '*Initial Brake Control Location*'.
- 7.12.6. For a vehicle equipped to tow a trailer which uses air at positive pressure;
- 7.12.6.1. When the service brake '*Control*' is operated through a full working stroke by an operator seated in the normal driving position, the pressure measured at the extremity of a pipe 2.5 m long with an internal diameter of 13 mm which must be joined to the '*Coupling Head*' of the '*Control Line 35/...*' must reach 420 kPa within 400 milliseconds of the instant the '*Control*' leaves the '*Initial Brake Control Location*'; and
- 7.12.6.2. in the case of hauling vehicles designed to be used in '*Road Train*' combinations, having fully applied the service brake '*Control*' and the pressure measured at the extremity of a pipe 2.5m long with an internal diameter of 13 mm which must be joined to the '*Coupling Head*' of the '*Control Line 35/...*' has stabilised, the service brake '*Control*' is fully released, the pressure measured at the extremity of the 2.5 m long pipe with an internal diameter of 13 mm joined to the '*Coupling Head*' of the '*Control Line 35/...*' must fall below 35 kPa within 650 milliseconds of the '*Control*' being released.
- 7.13. **Service Brake Compatibility Test**
- 7.13.1. Vehicles equipped to tow a trailer which uses air at positive pressure must be braked to a stop from initial speed of 60 km/h. For the first test a '*Control Signal*' of 0.2 '*E*' (130 kPa) measured at the '*Coupling Head*' must be used. Subsequent tests must be conducted increasing the '*Control Signal*' in increments of not greater than 0.2 '*E*' (130 kPa) until an '*Established Retardation Co-efficient*' of not less than 0.45 is reached. The vehicle must be laden to:

- 7.13.1.1. For vehicles not fitted with a ‘*Variable Proportioning Brake System*’ the manufacturer’s ‘*GVM*’ and in a separate test to the Group ‘*Axle Load*’ limits as specified in Table 2 if this results in a vehicle mass lower than the manufacturer’s ‘*GVM*’.
- 7.13.1.2. For vehicles fitted with a ‘*Variable Proportioning Brake System*’ the manufacturer’s ‘*GVM*’ and in a separate test to the ‘*Lightly Loaded Test Mass 35/..*’.
- 7.13.2. For the purposes of clause 4.1.10.2, where the vehicle has a ‘*Rated Towing Capacity*’ of more than 4.5 tonnes and the ‘*Manufacturer*’ elects not to provide certification which provides for the operation of trailer brakes using air at a positive pressure, the response of the ‘*Service Brake System*’ must be characterized as follows. The vehicle must be laden to the Group ‘*Axle Load*’ limits as specified in Table 2 or the manufacturers ‘*GVM*’ whichever is the lesser, and a series of tests conducted braking the vehicle to a stop from initial speed of 60 km/h. The output energy level of the ‘*Service Brake System*’, ‘*Control*’ and the ‘*ERC*’ achieved must be recorded for each test. For the first test an ‘*ERC*’ in the range 0.05 to 0.1 must be achieved. Subsequent tests must be conducted increasing the ‘*ERC*’ in not less than 5 evenly spaced steps until an ‘*ERC*’ of not less than 0.45 is reached. Where the vehicle is fitted with a ‘*Variable Proportioning Brake System*’, a further series of tests must be conducted with the vehicle laden to ‘*Lightly Loaded Test Mass 35/..*’.
- 7.13.3. The ‘*Service Brake System*’ ‘*ERC*’ must be determined according to the following as required:

$$ERC = \frac{0.00394V^2}{S - (0.278T_R V)}$$

$$ERC = \frac{0.0283V}{T - T_R}$$

where:

- V is the initial speed in km/h
 S is the ‘*Stopping Distance*’ in metres
 T is the ‘*Stopping Time*’ in seconds
 T_R is the response time measured from the time the ‘*Control*’ leaves the ‘*Initial Brake Control Location*’ until the energy level at the least favoured actuator reaches 65 per cent of ‘*Average Operating Pressure*’ and is measured in a separate test in accordance with clause 7.12.2 to 7.12.5.

7.14. **Alternative Procedures**

- 7.14.1. Where a vehicle design has a number of configurations such that the ‘*GVMs*’ of these configurations span more than one vehicle category, testing at the higher of these ‘*GVMs*’ will be deemed to demonstrate compliance at the lower of these ‘*GVMs*’ provided that any differences in ‘*Lightly Loaded Test Mass*’ are fully tested and, for vehicles not equipped with a ‘*Variable Proportioning Brake System*’, that the requirements of clause 7.13 are met at the lower ‘*GVMs*’.

- 7.14.2. For vehicles not fitted with a *'Variable Proportioning Brake System'*, where clause 7.13.1.1 requires two tests at different masses, or where the provisions in clause 7.14.1 are utilised, the *'ERC'* obtained by multiplying the *'ERC'* determined from 7.13.3 at the tested mass, by the tested mass in tonnes, and then dividing that figure by the alternative mass in tonnes, will be deemed to be the *'ERC'* for the alternative mass for the purposes of clause 4.1.9.

8. ALTERNATIVE STANDARDS

- 8.1. The technical requirements adopted by the United Nations – Economic Commission for Europe (UNECE) Regulation No. 13 – UNIFORM PROVISIONS CONCERNING THE APPROVAL OF VEHICLES OF CATEGORIES M, N AND O WITH REGARD TO BRAKING, incorporating any of the series of amendments from 10 to 11 for vehicles of category NA, or 5 to 11 for vehicles of category MD, ME, NB or NC, shall be deemed to be equivalent to the technical requirements of this standard, provided that, for hauling vehicles designed to be used in *'Road Train'* combinations, the requirements of clause 7.12.6.2 are met, and provided that vehicles of category MD4, ME, NB or NC are fitted with an *'Antilock System'*, and provided that vehicles of category NA are fitted with an Electronic Stability Control System and a Brake Assist System, both meeting the requirements of APPENDIX 2 of this standard.
- 8.1.1. On vehicles to which the coupling of a trailer is authorised, the parking braking system of the towing vehicle need not be capable of holding the combination of vehicles stationary on a 12 per cent up or down-gradient, provided that the requirements of clause 4.3.5 are met.
- 8.1.2. In respect of Annexes 18 of UNECE Regulation No. 13/10 and Annex 18 to 21 of 13/11, vehicles will be deemed to meet the requirements of these annexes if compliance can be demonstrated during a Conformity of Production assessment.
- 8.2. The technical requirements adopted by the United Nations – Economic Commission for Europe (UNECE) Regulation No. 13 – UNIFORM PROVISIONS CONCERNING THE APPROVAL OF VEHICLES OF CATEGORIES M, N AND O WITH REGARD TO BRAKING, incorporating the 11 series of amendments, Annex 21, for vehicles equipped with a stability function which includes roll-over control and directional control shall be deemed to be equivalent to the technical requirements of Part A of APPENDIX 2 of this standard for Electronic Stability Control for MB and MC category vehicles with a mass in running order > 1,735 kg and all NA category vehicles.
- 8.3. The technical requirements adopted by the United Nations – Economic Commission for Europe (UNECE) Regulation No. 13-H – UNIFORM PROVISIONS CONCERNING THE APPROVAL OF PASSENGER CARS WITH REGARD TO BRAKING, incorporating the 00 series of amendments from supplement 9 and corrigendum to supplement 9 onwards, Annex 9, shall be deemed to be equivalent to the technical requirements of APPENDIX 2 of this standard for Electronic Stability Control and Brake Assist Systems.

- 8.4. The technical requirements adopted by the United Nations - Economic Commission for Europe Global technical regulation No.8 – ELECTRONIC STABILITY CONTROL SYSTEMS, incorporating corrigenda 1 and 2, shall be deemed to be equivalent to the technical requirements of Part A of APPENDIX 2 of this standard.
- 8.4.1. The following exemptions to the provisions of Global technical regulation No.8 apply;
- 8.4.1.1. Clause 5.4. (f), where the ESC malfunction tell-tale need not illuminate if it is combined in a two-part telltale with the “ESC Off” tell-tale, and this is illuminated.
- 8.4.1.2. Clause 5.5.3.
- 8.4.1.3. Clause 6.3.1., where the ESC system must be enabled for all testing, except where otherwise specified in the text.
- 8.4.1.4. Clause 6.3.2., where the fuel tank need only be filled to at least 75 per cent of capacity.
- 8.4.1.5. Clause 6.3.4., where outriggers may be used for vehicles with a Static Stability Factor (SSF) > 1.25.
- 8.4.1.6. Clause 7.10.2., where the vehicle test speed need not be achieved within 30 seconds of starting the engine and more than one brake application may be made.
- 8.5. The technical requirements of Part III of COMMISSION REGULATION (EC) No. 631/2009 of 22 July 2009 laying down detailed rules for the implementation of Section 4 of Annex I to Regulation (EC) No. 78/2009 of the European Parliament and of the Council on the type-approval of motor vehicles with regard to the protection of pedestrians and other vulnerable road users shall be deemed to be equivalent to the technical requirements of Part B of APPENDIX 2 of this standard for Brake Assist Systems of vehicles of category NA.
- 8.6. The technical requirements adopted by the United Nations – Economic Commission for Europe (UNECE) Regulation No. 13-H – UNIFORM PROVISIONS CONCERNING THE APPROVAL OF PASSENGER CARS WITH REGARD TO BRAKING, incorporating the 00 series of amendments from supplement 9 and corrigendum to supplement 9 onwards, Annex 6, shall be deemed to be equivalent to the technical requirements of APPENDIX 1 of this standard for ‘*Antilock Systems*’ of vehicles of category MB, MC or NA.
- 8.7. The technical requirements adopted by the United Nations – Economic Commission for Europe (UNECE) Regulation No. 13 – UNIFORM PROVISIONS CONCERNING THE APPROVAL OF VEHICLES OF CATEGORIES M, N AND O WITH REGARD TO BRAKING, incorporating the 11 series of amendments, paragraph 5.2.1.22, shall be deemed to be equivalent to the technical requirements of clause 4.1.5.1 and APPENDIX 1 of this standard for ‘*Antilock Systems*’ of vehicles of category MD, ME, NB or NC.

**TABLE 1
TESTS AND PROCEDURES**

Item No.*	Tests and Procedures	Vehicle Category	Initial Speed (km/h)	Minimum 'Average Deceleration' (m/s ²)	Vehicle Mass	Gear Selector	Maximum 'Control' Force (N)
1.	Pre-test Instrumentation Check	All	40 Max.	See Text	—	—	—
2.	Service Brake Burnishing Procedure (optional)	All	See Text	See Text	—	—	—
3.	Service Brake Lightly Laden Effectiveness Test	MB,MC,MD,ME NA,NB,NC,LEG	100 100	4.19 3.78	L	N	685
4.	Lightly Laden Secondary Brake Test	MB,MC,MD,ME NA,LEG NB NC	60 70 50 40	2.10 2.0 1.85 1.80	L	N	590 (hand) 685 (foot)
5.	Lightly Laden Partial Failure Test	MB,MC,MD,ME NA,LEG NB NC	60 70 50 40	2.10 2.00 1.85 1.80	L	N	685
6.	Service Brake Laden Effectiveness Test	MB,MC,MD,ME NA,NB,NC,LEG	100 100	4.19 3.78	M	N	685
7.	Laden Secondary Brake Test	MB,MC,MD,ME NA,LEG NB NC	60 70 50 40	2.10 2.0 1.85 1.80	M	N	590 (hand) 685 (foot)
8.	Laden Partial Failure Test	MB,MC,MD,ME NA,LEG NB NC	60 70 50 40	2.10 2.00 1.85 1.80	M	N	See Text
9.	Service Brake Fade	All	See Text	See Text	M	D	See Text
10.	Service Brake Fade Effectiveness Check	MB,MC,MD,ME NA,LEG NB NC	60 70 50 40	3.02 2.84 2.63 2.47	M	N	685

Item No.*	Tests and Procedures	Vehicle Category	Initial Speed (km/h)	Minimum 'Average Deceleration' (m/s ²)	Vehicle Mass	Gear Selector	Maximum 'Control' Force (N)
11.	Parking Brake Test	All	—	—	M	N	590(hand) 685(foot)
12.	Service Brake Actuating Time Test	See Text	N.A.	N.A.	N.A.	N.A.	See Text
13.	Service Brake Compatibility Test	See Text	60	See Text	See Text	N	685

* Item No. also corresponds to sub-clause number of clause 7.

“M” means ‘Maximum Loaded Test Mass 35/...’ .

“L” means ‘Lightly Loaded Test Mass 35/...’ .

“D” means transmission control in “drive” position appropriate to test speed.

“N” means transmission control in “neutral” position

“R” means transmission control in “reverse” position

“N.A.” means not applicable

TABLE 2
GROUP 'AXLE LOAD' LIMITS

Number of 'Axles' in 'Axle Group'	Tyre Type "a" and Configuration	Group 'Axle Load' Limit (tonnes)
1	S D W ₁ W ₂ D	6.0 9.0 6.7 7.0 10.0 (RFS)
2	S S S D W ₁ W ₁ D D W ₂ W ₂ D D	11.0 13.0 13.3 16.5 14 17.0 (RFS)
3	S S S D D D W ₁ W ₁ W ₁ or W ₂ W ₂ W ₂ D D D	15 20.0 20.0 22.5 (RFS)

Tyre Type "a":

- S Single tyre per wheel
- D Dual tyres per wheel
- W₁ 'Wide Single Tyre' (375 to 450 mm width)
- W₂ 'Wide Single Tyre' (over 450 mm width)
- RFS 'Road Friendly Suspension' (Note: for information only. Not part of this standard).

TABLE 3
CONSTANTS FOR DETERMINING AVERAGE DECELERATION

TEST	CATEGORY	K ₁	K ₂
Service Brake Effectiveness Tests	MB, MC, MD, ME	1.0	130
	LEG, NA, NB, NC	1.0	115
Secondary Brake Tests	MB, MC, MD, ME	1.0	65
	LEG, NA, NB, NC	1.67	115
Fade Effectiveness Test	MB, MC, MD, ME	1.25	130
Effectiveness Checks	LEG, NA, NB, NC	1.25	115

FIGURE 1
SERVICE BRAKE EFFECTIVENESS

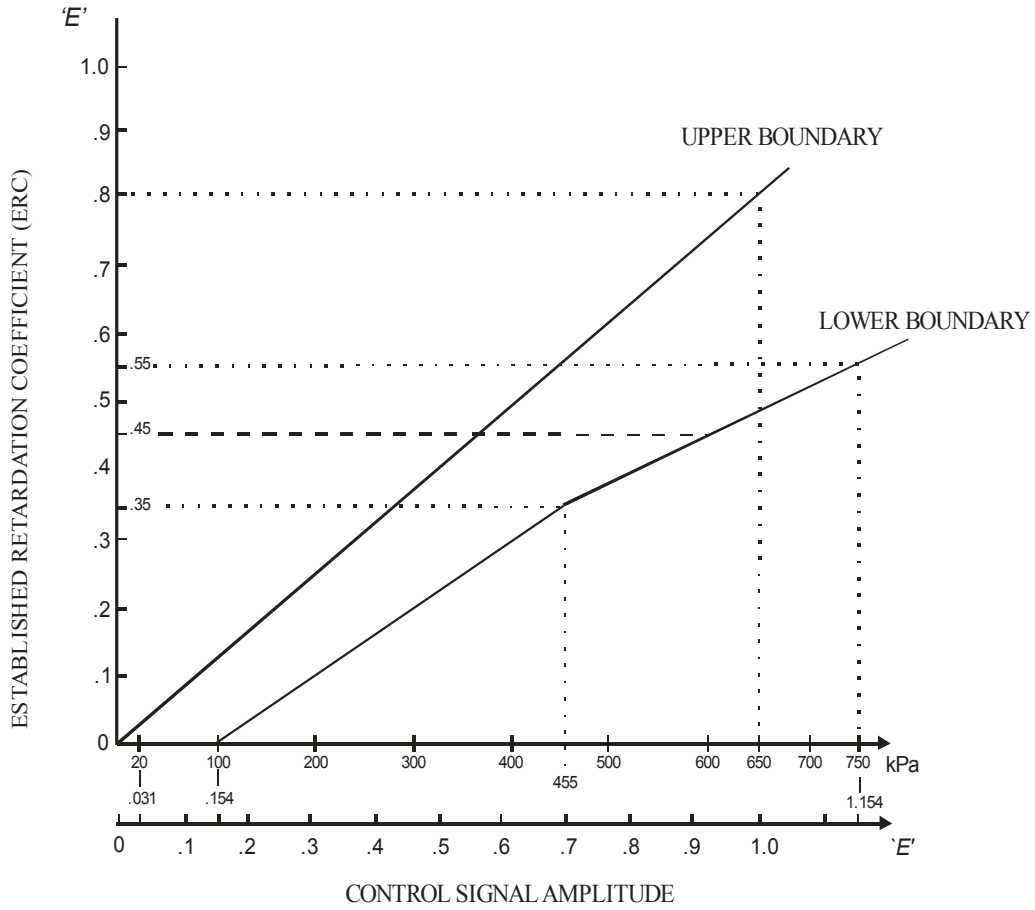
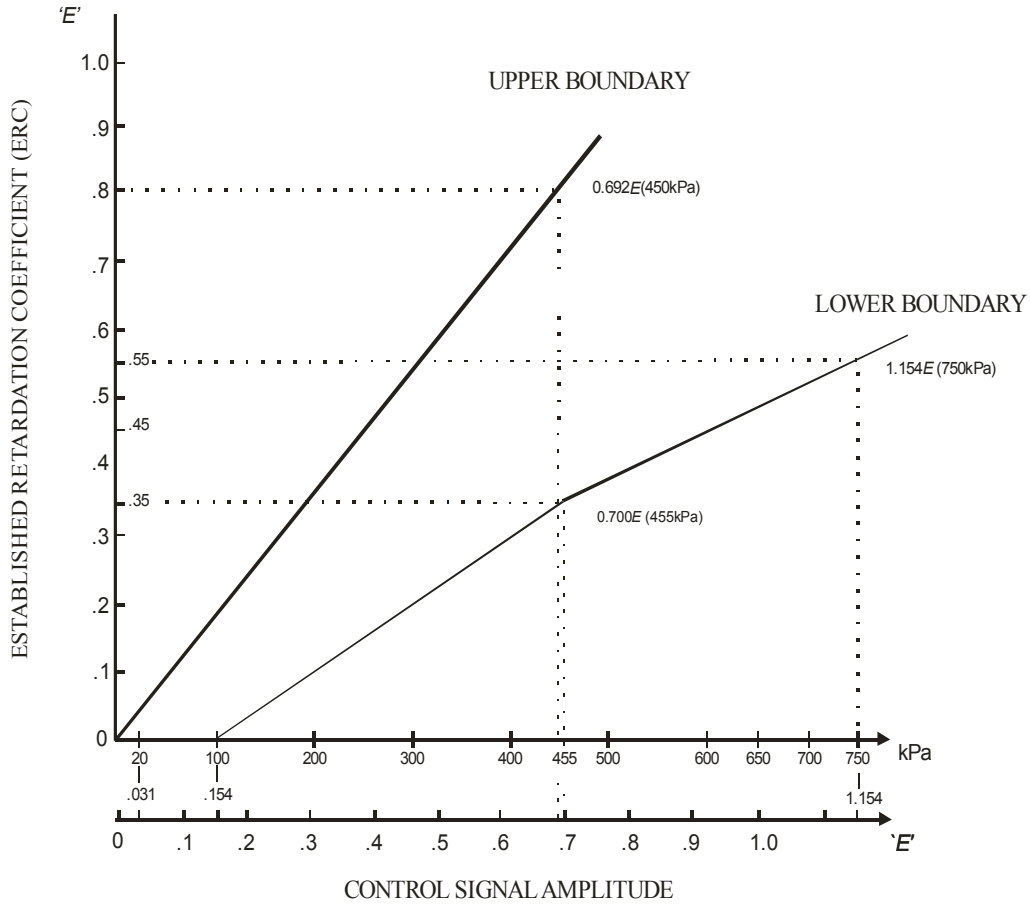


FIGURE 2
 'LIGHTLY LOADED TEST MASS'
 SERVICE BRAKE EFFECTIVENESS



Note: The relationship required by the diagram shall apply progressively for the intermediate states of loading between the maximum mass tested (Figure 1) and the 'LLTM' (Figure 2) states and shall be achieved by automatic means.

APPENDIX 1

Provisions for all vehicles incorporating an ‘*Antilock System*’.

- 1.1 At speeds exceeding 15 km/h, the wheels on at least one axle in each axle group must remain unlocked when a ‘*Control*’ force of 685 N is suddenly applied on the ‘*Control*’ or in the case of a ‘*Control*’ which solely modulates ‘*Stored Energy*’, full stroke of the ‘*Control*’ is suddenly applied, when braking from an initial speed of 40 km/h and also from an initial speed of 80 km/h (or greater) on a road surface having approximately uniform surface friction on both sides of the vehicle.
- 1.1.1 This test is to be performed with the vehicle laden to ‘*Lightly Loaded Test Mass 35/...*’ and again with the vehicle laden to ‘*Maximum Loaded Test Mass 35/...*’.
- 1.1.2 Brief periods of locking of the wheels will, however, be allowed but stability must not be affected.
- 1.1.3 The general test conditions from part 7 and the particular test conditions from clauses 7.3 and 7.6 including the requirements for deceleration must be used except that the requirements of this clause must be met on each test.
- 1.1.4 These tests can be combined with those required in clauses 7.3 and 7.6. and can be conducted at any point in the brake test sequence.
- 1.2 Any break in the supply of electricity to the ‘*Antilock System*’ and any electrical failure of the ‘*Antilock System*’ must be signalled to the driver by an optical warning signal appropriately labelled and located in accordance with clause 4.2.12. The lamp may be common with or distinct and separate from any ‘*Service Brake System*’ failure ‘*Visible Indicator*’ lamp.
- 1.2.1 In case of NC category vehicles, the warning signal must be;
- 1.2.1.1 red or yellow if after the failure of ‘*Antilock System*’, the vehicle meets the performance requirements of all tests specified in part 7.
- 1.2.1.2 red, if after the failure of ‘*Antilock System*’, the vehicle does not meet the performance requirements of all tests specified in part 7.
- 1.2.2 In case of vehicles other than NC category vehicles, the warning light must be red or yellow.
- 1.2.3 The warning signal must light up when the ‘*Antilock System*’ is energised and must go off after not less than 2 seconds or at the latest when the vehicle reaches a speed of 15 km/h and no defect is present.
- 1.3 Where a vehicle is equipped to tow a trailer with an ‘*ATM*’ of more than 4.5 tonnes and it is fitted with an electrical connection for the ‘*Antilock System*’:

- 1.3.1 The vehicle must have a permanent electrical supply system for connection to trailers using a special connector conforming to DIN Standard 72570 configured for 12 volt operation or ISO/DIN 7638:1996, 1997 or 2003 configured for 12 or 24 volt operation. The voltage must be marked on the plug and a warning label must be provided in the cabin to warn the driver. The power supply must provide DC current having a nominal voltage level of 12 volts or 24 volts.
- 1.3.2 The connector must be wired to have the following functions:
- 1.3.2.1 For 12 volt operation
Pin 1 +ve high current trailer solenoid valve supply, 20 amps minimum continuous rated capacity 30 amps maximum capacity
Pin 2 +ve low current trailer electronic unit supply, 4 amps minimum rated capacity
Pin 3 -ve low current trailer electronic unit supply, 6 amps minimum rated capacity
Pin 4 -ve high current trailer solenoid valve supply, 20 amps minimum continuous rated capacity 30 amps maximum capacity
Pin 5 trailer '*Antilock System*' failure, switched to -ve (eg pin 3 or pin 4) upon fault detection, 2 amps minimum rated capacity.
- 1.3.2.2 For 24 volt operation
Pin 1 +ve high current trailer solenoid valve supply, 10 amps minimum continuous rated capacity 15 amps maximum capacity
Pin 2 +ve low current trailer electronic unit supply, 2 amps minimum rated capacity
Pin 3 -ve low current trailer electronic unit supply, 3 amps minimum rated capacity
Pin 4 -ve high current trailer solenoid valve supply, 10 amps minimum continuous rated capacity 15 amps maximum capacity
Pin 5 trailer '*Antilock System*' failure, switched to -ve (eg pin 3 or pin 4) upon fault detection, 1 amp minimum rated capacity.
- 1.3.3 Either the optical warning lamp specified in clause 1.2.1 of this APPENDIX or an additional yellow optical warning signal (appropriately labelled) must light up whenever Pin 5 of the connector specified in clause 1.3.2 of this APPENDIX is connected to ground or a -ve connector.

APPENDIX 1 – Annex 1

Additional Provisions for vehicles of categories MD4, ME, NB or NC.

- 1.1 Where a vehicle is equipped to tow a trailer, it must be fitted with an electrical connection for the '*Antilock System*' meeting Appendix 1 clauses 1.3.1 to 1.3.3.
- 1.1.1 Where the vehicle also provides an electrical '*Control Signal*' via an electric '*Control Line*', the electrical connection shall conform to ISO 11992-1 and 11992-2:2003 and be a point-to-point type using the seven pin connector according to ISO 7638-1 or 7638-2:1997. The data contacts of the ISO 7368 connector shall be used to transfer information exclusively for braking (including the '*Antilock System*') and running gear (steering, tyres and suspension) functions as specified in ISO 11992-2:2003.

The braking functions have priority and shall be maintained in the normal and failed modes. The transmission of running gear information shall not delay braking functions. The power supply, provided by the ISO 7638 connector, shall be used exclusively for braking and running gear functions and that required for the transfer of trailer related information not transmitted via the electric '*Control Line*'.

However, in all cases, whenever power supplied by the ISO 7638:2003 connector is used for the functions defined in this paragraph above, the braking system shall have priority and be protected from an overload external to the braking system. This protection shall be a function of the braking system. The power supply for all other functions shall use other measures. Whenever power supplied by the ISO 7638:1997 connector is used for the functions defined above, the braking system shall have priority and be protected from an overload external to the braking system. This protection shall be a function of the braking system.

APPENDIX 2

Special Provisions for vehicles incorporating an Electronic Stability Control System and a Brake Assist System where required by Clause 4.1.1.1.

The following is a modified form of Annex 9 of UNECE Regulation No. 13-H- UNIFORM PROVISIONS CONCERNING THE APPROVAL OF PASSENGER CARS WITH REGARD TO BRAKING, incorporating supplement 14 to the 00 series of amendments.

0. DEFINITIONS

- 0.1. "Ackerman steer angle" means the angle whose tangent is the wheelbase divided by the radius of the turn at a very low speed.
- 0.2. "Electronic Stability Control System" or "ESC System" means a system that has all of the following attributes:
 - 0.3. That improves vehicle directional stability by at least having the ability to automatically control individually the braking torques of the left and right wheels on each axle ^{1/} to induce a correcting yaw moment based on the evaluation of actual vehicle behaviour in comparison with a determination of vehicle behaviour demanded by the driver;
 - 0.4. That is computer controlled with the computer using a closed-loop algorithm to limit vehicle oversteer and to limit vehicle understeer based on the evaluation of actual vehicle behaviour in comparison with a determination of vehicle behaviour demanded by the driver;
 - 0.5. That has a means to determine directly the value of the vehicle's yaw rate and to estimate its side-slip or side-slip derivative with respect to time;
 - 0.6. That has a means to monitor driver steering inputs; an
 - 0.7. That has an algorithm to determine the need, and a means to modify propulsion torque, as necessary, to assist the driver in maintaining control of the vehicle.
- 0.8. "Lateral acceleration" means the component of the acceleration vector of a point in the vehicle perpendicular to the vehicle x axis (longitudinal) and parallel to the road plane.
- 0.9. "Oversteer" means a condition in which the vehicle's yaw rate is greater than the yaw rate that would occur at the vehicle's speed as a result of the Ackerman steer angle.
- 0.10. "Side-slip or side-slip angle" means the arctangent of the ratio of the lateral velocity to the longitudinal velocity of the centre of gravity of the vehicle.
- 0.11. "Understeer" means a condition in which the vehicle's yaw rate is less than the yaw rate that would occur at the vehicle's speed as a result of the Ackerman steer angle.

^{1/} An axle group shall be treated as a single axle and dual wheels shall be treated as a single wheel.

- 0.12. "Yaw rate" means the rate of change of the vehicle's heading angle measured in degrees/second of rotation about a vertical axis through the vehicle's centre of gravity.
- 0.13. "Peak braking coefficient (PBC)": means the measure of tyre to road surface friction based on the maximum deceleration of a rolling tyre.
- 0.14. "Common space" means an area on which more than one tell-tale, indicator, identification symbol, or other message may be displayed but not simultaneously.
- 0.15. "Static stability factor" means one-half the track width of a vehicle divided by the height of its center of gravity, also expressed as $SSF = T/2H$, where: T = track width (for vehicles with more than one track width the average is used; for axles with dual wheels, the outer wheels are used when calculating "T") and H = height of the center of gravity of the vehicle.
- 0.16. "Brake Assist System (BAS)" means a function of the braking system that deduces an emergency braking event from a characteristic of the driver's brake demand and, under such conditions:
- (a) Assists the driver to deliver the maximum achievable braking rate; or
 - (b) Is sufficient to cause full cycling of the Anti-lock Braking System.
- 0.16.1. "Category A Brake Assist System" means a system which detects an emergency braking condition based primarily^{2/} on the brake pedal force applied by the driver.
- 0.16.2. "Category B Brake Assist System" means a system which detects an emergency braking condition based primarily^{2/} on the brake pedal speed applied by the driver.

A. REQUIREMENTS FOR ELECTRONIC STABILITY CONTROL SYSTEMS

1. GENERAL REQUIREMENTS

- 1.1. Every ESC system must comply with the definition of paragraph 0.2 of this appendix and shall meet the equipment, performance and test requirements contained in this appendix.
- 1.2. Vehicles equipped with an ESC system shall meet the functional requirements specified in paragraph 2. and the performance requirements in paragraph 3. under the test procedures specified in paragraph 4. and under the test conditions specified in paragraph 5. of this appendix.

2. FUNCTIONAL REQUIREMENTS

Each vehicle to which this appendix applies shall be equipped with an electronic stability control system that:

^{2/} As declared by the vehicle manufacturer.

- 2.1. Is capable of applying braking torques individually to all four wheels ^{1/} and has a control algorithm that utilizes this capability;
- 2.2. Is operational over the full speed range of the vehicle, during all phases of driving including acceleration, coasting, and deceleration (including braking), except:
 - 2.2.1. When the driver has disabled ESC;
 - 2.2.2. When the vehicle speed is below 20 km/h;
 - 2.2.3. While the initial start-up self test and plausibility checks are completed, not to exceed 2 minutes when driven under the conditions of paragraph 5.10.2.;
 - 2.2.4. When the vehicle is being driven in reverse.
- 2.3. Remains capable of activation even if the antilock braking system or traction control system is also activated.

3. PERFORMANCE REQUIREMENTS

During each test performed under the test conditions of paragraph 4. and the test procedure of paragraph 5.9., the vehicle with the ESC system engaged shall satisfy the directional stability criteria of paragraphs 3.1. and 3.2., and it shall satisfy the responsiveness criterion of paragraph 3.3. during each of those tests conducted with a commanded steering wheel ^{3/} angle of $5A$ or greater but limited as per paragraph 5.9.4., where A is the steering wheel angle computed in paragraph 5.6.1.

Where a vehicle has been physically tested in accordance with paragraph 4., the compliance of versions or variants of that same vehicle type may be demonstrated by a computer simulation, which respects the test conditions of paragraph 4. and the test procedure of paragraph 5.9. The use of the simulator is defined in Attachment 1 to this appendix.

- 3.1. The yaw rate measured 1 second after completion of the Sine with Dwell steering input (time $T_0 + 1$ in Figure 1) shall not exceed 35 percent of the first peak value of yaw rate recorded after the steering wheel angle changes sign (between first and second peaks) ($\dot{\psi}_{Peak}$ in Figure 1) during the same test run.

^{3/} The text in this appendix assumes that the vehicle steering is controlled by means of a steering wheel. Vehicles using other types of steering control may also be approved to this appendix provided the manufacturer is able to demonstrate to the technical service that the performance requirements of this appendix can be met using equivalent steering inputs to the steering inputs stipulated under paragraph 5. of this appendix.

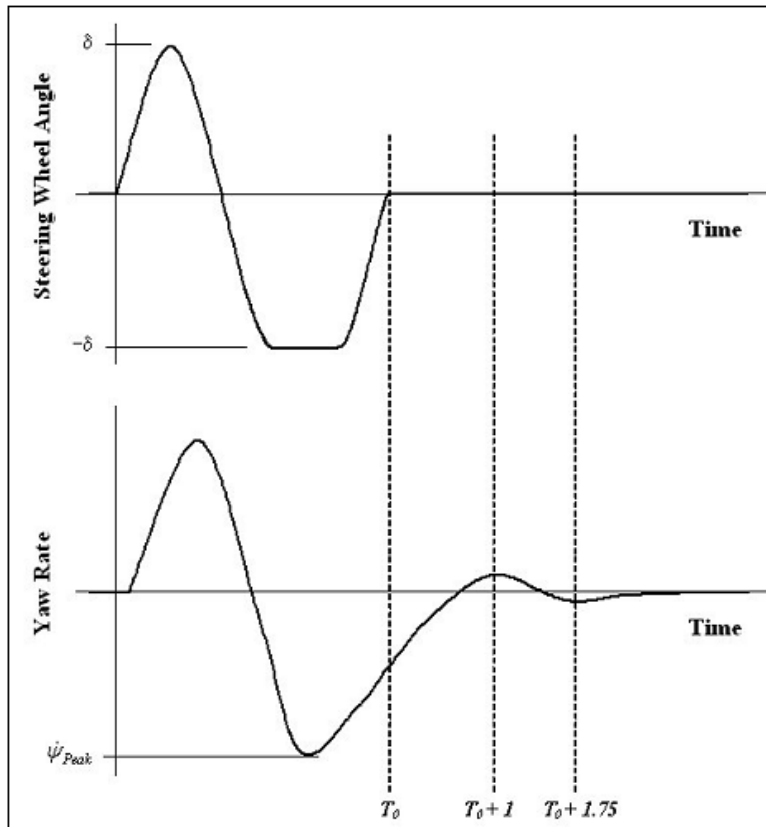


Figure 1. Steering wheel position and yaw velocity information used to assess lateral stability.

- 3.2. The yaw rate measured 1.75 seconds after completion of the Sine with Dwell steering input shall not exceed 20 percent of the first peak value of yaw rate recorded after the steering wheel angle changes sign (between first and second peaks) during the same test run.
- 3.3. The lateral displacement of the vehicle centre of gravity with respect to its initial straight path shall be at least 1.83 m for vehicles with a GVM of 3,500 kg or less, and 1.52 m for vehicles with a maximum mass greater than 3,500 kg when computed 1.07 seconds after the Beginning of Steer (BOS). BOS is defined in paragraph 5.11.6.
- 3.3.1. The computation of lateral displacement is performed using double integration with respect to time of the measurement of lateral acceleration at the vehicle centre of gravity, as expressed by the formula:

$$\text{Lateral Displacement} = \iint a_{y_{C.G.}} dt$$

An alternative measuring method may be allowed for type approval testing, provided it demonstrates at least an equivalent level of precision as the double integration method.

- 3.3.2. Time $t = 0$ for the integration operation is the instant of steering initiation, known as the Beginning of Steer (BOS). BOS is defined in paragraph 5.11.6.

3.4. ESC malfunction detection

The vehicle shall be equipped with a tell-tale that provides a warning to the driver of the occurrence of any malfunction that affects the generation or transmission of control or response signals in the vehicle's electronic stability control system.

3.4.1. The ESC malfunction tell-tale:

3.4.1.1. Shall be displayed in direct and clear view of the driver, while in the driver's designated seating position with the driver's seat belt fastened;

3.4.1.2. Shall appear perceptually upright to the driver while driving;

3.4.1.3. Shall be identified by the symbol shown for "ESC Malfunction Tell-tale" below or the text "ESC":



3.4.1.4. Shall be yellow or amber in colour;

3.4.1.5. When illuminated must be sufficiently bright to be visible to the driver under both daylight and night-time driving conditions, when the driver has adapted to the ambient roadway light conditions;

3.4.1.6. Except as provided in paragraph 3.4.1.7., the ESC malfunction tell-tale shall illuminate when a malfunction exists and shall remain continuously illuminated under the conditions specified in paragraph 3.4. for as long as the malfunction exists, whenever the ignition locking system is in the "On" ("Run") position;

3.4.1.7. Except as provided in paragraph 3.4.2., each ESC malfunction tell-tale shall be activated as a check of lamp function either when the ignition locking system is turned to the "On" ("Run") position when the engine is not running, or when the ignition locking system is in a position between "On" ("Run") and "Start" that is designated by the manufacturer as a check position;

3.4.1.8. Shall extinguish at the next ignition cycle after the malfunction has been corrected in accordance with paragraph 5.10.4.;

3.4.1.9. May also be used to indicate the malfunction of related systems/functions, including traction control, trailer stability assist, corner brake control, and

other similar functions that use throttle and/or individual torque control to operate and share common components with ESC.

3.4.2. The ESC malfunction tell-tale need not be activated when a starter interlock is in operation.

3.4.3. The requirement of paragraph 3.4.1.7. does not apply to tell-tales shown in a common space.

3.4.4. The manufacturer may use the ESC malfunction tell-tale in a flashing mode to indicate ESC intervention and/or the intervention of ESC-related systems (as listed in paragraph 3.4.1.9.).

3.5. ESC Off and other system controls

The manufacturer may include an "ESC Off" control, which shall be illuminated when the vehicle's headlamps are activated, and which has a purpose to place the ESC system in a mode in which it will no longer satisfy the performance requirements of paragraphs 3., 3.1., 3.2. and 3.3. Manufacturers may also provide controls for other systems that have an ancillary effect upon ESC operation. Controls of either kind that place the ESC system in a mode in which it may no longer satisfy the performance requirements of paragraphs 3., 3.1., 3.2. and 3.3. are permitted, provided that the system also meets the requirements of paragraphs 3.5.1., 3.5.2. and 3.5.3.

3.5.1. The vehicle's ESC system shall always return to the manufacturer's original default mode that satisfies the requirements of paragraphs 2. and 3. at the initiation of each new ignition cycle, regardless of what mode the driver had previously selected. However, the vehicle's ESC system need not return to a mode that satisfies the requirements of paragraphs 3. through 3.3. at the initiation of each new ignition cycle if:

3.5.1.1. The vehicle is in a four-wheel drive configuration which has the effect of locking the drive gears at the front and rear axles together and providing an additional gear reduction between the engine speed and vehicle speed of at least 1.6, selected by the driver for low-speed, off-road driving; or

3.5.1.2. The vehicle is in a four-wheel drive configuration selected by the driver that is designed for operation at higher speeds on snow-, sand-, or dirt-packed roads and that has the effect of locking the drive gears at the front and rear axles together, provided that in this mode the vehicle meets the stability performance requirements of paragraphs 3.1. and 3.2. under the test conditions specified in paragraph 4. However, if the system has more than one ESC mode that satisfies the requirements of paragraphs 3.1. and 3.2. within the drive configuration selected for the previous ignition cycle, the ESC shall return to the manufacturer's original default ESC mode for that drive configuration at the initiation of each new ignition cycle.

- 3.5.2. A control, whose only purpose is to place the ESC system in a mode in which it will no longer satisfy the performance requirements of paragraphs 3., 3.1., 3.2. and 3.3., shall be identified by the symbol shown for "ESC Off" below or the text "ESC OFF".



- 3.5.3. A control for an ESC system whose purpose is to place the ESC system in different modes, at least one of which may no longer satisfy the performance requirements of paragraphs 3., 3.1., 3.2., and 3.3., shall be identified by the symbol below with the text "OFF" adjacent to the control position for this mode.



Alternatively, in the case where the ESC system mode is controlled by a multi-functional control, the driver display shall identify clearly to the driver the control position for this mode using either the symbol in paragraph 3.5.2. or the text "ESC OFF".

- 3.5.4. A control for another system that has the ancillary effect of placing the ESC system in a mode in which it no longer satisfies the performance requirements of paragraphs 3., 3.1., 3.2. and 3.3. need not be identified by the "ESC Off" symbol of paragraph 3.5.2.

3.6. ESC OFF tell-tale

If the manufacturer elects to install a control to turn off or reduce the performance of the ESC system under paragraph 3.5., the tell-tale requirements of paragraphs 3.6.1. to 3.6.4. shall be met in order to alert the driver to the inhibited or reduced state of ESC system functionality. This requirement does not apply for the driver-selected mode referred to in paragraph 3.5.1.2.

- 3.6.1. The vehicle manufacturer shall provide a tell-tale indicating that the vehicle has been put into a mode that renders it unable to satisfy the requirements of paragraphs 3., 3.1., 3.2. and 3.3., if such a mode is provided.
- 3.6.2. The "ESC Off" tell-tale:
- 3.6.2.1. Shall be displayed in direct and clear view of the driver while in the driver's designated seating position with the driver's seat belt fastened;
- 3.6.2.2. Shall appear perceptually upright to the driver while driving;
- 3.6.2.3. Shall be identified by the symbol shown for "ESC Off" below or the text "ESC OFF",



or

Shall be identified with the English word "OFF" adjacent to either the control referred to in paragraph 3.5.2. or 3.5.3. or the illuminated malfunction tell-tale;

- 3.6.2.4. Shall be yellow or amber in colour;
- 3.6.2.5. When illuminated, shall be sufficiently bright to be visible to the driver under both daylight and night time driving conditions, when the driver has adapted to the ambient roadway light conditions;
- 3.6.2.6. Shall remain continuously illuminated for as long as the ESC is in a mode that renders it unable to satisfy the requirements of paragraphs 3., 3.1., 3.2. and 3.3;
- 3.6.2.7. Except as provided in paragraphs 3.6.3. and 3.6.4. each "ESC Off" tell-tale shall be activated as a check of lamp function either when the ignition locking system is turned to the "On" ("Run") position when the engine is not running, or when the ignition locking system is in a position between "On" ("Run") and "Start" that is designated by the manufacturer as a check position.
- 3.6.2.8. Shall extinguish after the ESC system has been returned to the manufacturer's original default mode.
- 3.6.3. The "ESC Off" tell-tale need not be activated when a starter interlock is in operation.
- 3.6.4. The requirement of paragraph 3.6.2.7. of this appendix does not apply to tell-tales shown in a common space.
- 3.6.5. The manufacturer may use the "ESC Off" tell-tale to indicate an ESC level of function other than the manufacturer's original default mode even if the vehicle would meet paragraphs 3., 3.1., 3.2. and 3.3. of this appendix at that level of ESC function.
- 3.7. ESC system technical documentation

Further to the requirements defined in Appendix 2 – Attachment 6 to this standard, the manufacturer shall, as confirmation that the vehicle is equipped with an ESC system that meets the definition of an "ESC System" as in paragraph 0.2. to this appendix, include the vehicle manufacturer's documentation as specified in paragraphs 3.7.1. to 3.7.4. below.

- 3.7.1. System diagram identifying all ESC system hardware. The diagram shall identify those components that are used to generate brake torques at each wheel, determine vehicle yaw rate, estimated side-slip or the side-slip derivative and driver steering inputs.
- 3.7.2. A brief written explanation sufficient to describe the ESC system's basic operational characteristics. This explanation shall include the outline description of the system's capability to apply braking torques at each wheel and how the system modifies propulsion torque during ESC system activation, and show that the vehicle yaw rate is directly determined even under the conditions where no wheel speed information is available. The explanation shall also specify the vehicle speed range and the driving phases (acceleration, deceleration, coasting, during activation of the ABS or traction control) under which the ESC system can activate.
- 3.7.3. Logic diagram. This diagram supports the explanation provided under paragraph 3.7.2.
- 3.7.4. Understeer information. An outline description of the pertinent inputs to the computer that control ESC system hardware and how they are used to limit vehicle understeer.

4. TEST CONDITIONS

4.1. Ambient conditions

- 4.1.1. The ambient temperature is between 0 °C and 45 °C.
- 4.1.2. The maximum wind speed is no greater than 10 m/s for vehicles with $SSF > 1.25$, and 5 m/s for vehicles with $SSF \leq 1.25$.

4.2. Road test surface

- 4.2.1. Tests are conducted on a dry, uniform, solid-paved surface. Surfaces with irregularities and undulations, such as dips and large cracks, are unsuitable.
- 4.2.2. The road test surface has a nominal^{4/} peak braking coefficient (PBC) of 0.9, unless otherwise specified, when measured using either:
- 4.2.2.1. The American Society for Testing and Materials (ASTM) E1136 standard reference test tyre, in accordance with ASTM Method E1337-90, at a speed of 40 mph; or
- 4.2.2.2. The k-test method specified in Appendix 2 – Attachment 7 of this standard.
- 4.2.3. The test surface has a consistent slope between level and 1 per cent.

^{4/} The "nominal" value is understood as being the theoretical target value.

4.3. Vehicle conditions

4.3.1. The ESC system is enabled for all testing.

4.3.2. Vehicle mass. The vehicle is loaded with the fuel tank filled to at least 90 per cent of capacity, and a total interior load of 168 kg comprised of the test driver, approximately 59 kg of test equipment (automated steering machine, data acquisition system and the power supply for the steering machine), and ballast as required to make up for any shortfall in the weight of test drivers and test equipment. Where required, ballast shall be placed on the floor behind the passenger front seat or if necessary in the front passenger foot well area. All ballast shall be secured in a way that prevents it from becoming dislodged during testing.

4.3.3. Tyres. The tyres are inflated to the vehicle manufacturer's recommended cold inflation pressure(s) e.g. as specified on the vehicle's placard or the tyre inflation pressure label. Tubes may be installed to prevent tyre de-beading.

4.3.4. Outriggers. Outriggers may be used for testing if deemed necessary for test drivers' safety. In this case, the following applies for vehicles with a Static Stability Factor (SSF) ≤ 1.25 :

4.3.4.1. Vehicles with a mass in running order under 1,588 kg shall be equipped with "lightweight" outriggers. Lightweight outriggers shall be designed with a maximum mass of 27 kg and a maximum roll moment of inertia of $27 \text{ kg}\cdot\text{m}^2$.

4.3.4.2. Vehicles with a mass in running order between 1,588 kg and 2,722 kg shall be equipped with "standard" outriggers. Standard outriggers shall be designed with a maximum mass of 32 kg and a maximum roll moment of inertia of $35.9 \text{ kg}\cdot\text{m}^2$.

4.3.4.3. Vehicles with a mass in running order equal to or greater than 2,722 kg shall be equipped with "heavy" outriggers. Heavy outriggers shall be designed with a maximum mass of 39 kg and a maximum roll moment of inertia of $40.7 \text{ kg}\cdot\text{m}^2$.

4.3.5. Automated steering machine. A steering robot programmed to execute the required steering pattern shall be used in paragraphs 5.5.2., 5.5.3., 5.6. and 5.9. The steering machine shall be capable of supplying steering torques between 40 to 60 Nm. The steering machine shall be able to apply these torques when operating with steering wheel velocities up to 1,200 degrees per second.

5. Test Procedure

5.1. Inflate the vehicles' tyres to the manufacturer's recommended cold inflation pressure(s) e.g. as provided on the vehicle's placard or the tyre inflation pressure label.

- 5.2. Tell-tale bulb check. With the vehicle stationary and the ignition locking system in the "Lock" or "Off" position, switch the ignition to the "On" ("Run") position or, where applicable, the appropriate position for the lamp check. The ESC malfunction tell-tale shall be illuminated as a check of lamp function, as specified in paragraph 3.4.1.7., and if equipped, the "ESC Off" tell-tale shall also be illuminated as a check of lamp function, as specified in paragraph 3.6.2.7. The tell-tale bulb check is not required for a tell-tale shown in a common space as specified in paragraphs 3.4.3. and 3.6.4.
- 5.3. "ESC Off" control check. For vehicles equipped with an "ESC Off" control, with the vehicle stationary and the ignition locking system in the "Lock" or "Off" position, switch the ignition locking system to the "On" ("Run") position. Activate the "ESC Off" control and verify that the "ESC Off" tell-tale is illuminated, as specified in paragraph 3.6.2. Turn the ignition locking system to the "Lock" or "Off" position. Again, switch the ignition locking system to the "On" ("Run") position and verify that the "ESC Off" tell-tale has extinguished indicating that the ESC system has been restored as specified in paragraph 3.5.1.
- 5.4. Brake conditioning
- Condition the vehicle brakes in the manner described in paragraphs 5.4.1. to 5.4.4.
- 5.4.1. Ten stops are performed from a speed of 56 km/h, with an average deceleration of approximately 0.5g.
- 5.4.2. Immediately following the series of ten 56 km/h stops, three additional stops are performed from 72 km/h at higher deceleration.
- 5.4.3. When executing the stops in paragraph 5.4.2., sufficient force is applied to the brake pedal to bring the vehicle's antilock braking system (ABS) into operation for a majority of each braking event.
- 5.4.4. Following completion of the final stop in 5.4.2., the vehicle is driven at a speed of 72 km/h for five minutes to cool the brakes.
- 5.5. Tyre Conditioning
- Condition the tyres using the procedure of paragraphs 5.5.1. to 5.5.3. to wear away mould sheen and achieve operating temperature immediately before beginning the test runs of paragraphs 5.6. and 5.9.
- 5.5.1. The test vehicle is driven around a circle 30 meters in diameter at a speed that produces a lateral acceleration of approximately 0.5 to 0.6g for three clockwise laps followed by three anticlockwise laps.

- 5.5.2. Using a sinusoidal steering pattern at a frequency of 1 Hz, a peak steering wheel angle amplitude corresponding to a peak lateral acceleration of 0.5 to 0.6g, and a vehicle speed of 56 km/h, the vehicle is driven through four passes performing 10 cycles of sinusoidal steering during each pass.
- 5.5.3. The steering wheel angle amplitude of the final cycle of the final pass shall be twice that of the other cycles. The maximum time permitted between each of the laps and passes is five minutes.

5.6. Slowly increasing steer procedure

The vehicle is subjected to two series of runs of the slowly increasing steer test using a constant vehicle speed of 80 ± 2 km/h and a steering pattern that increases by 13.5 degrees per second until a lateral acceleration of approximately 0.5g is obtained. Three repetitions are performed for each test series. One series uses anticlockwise steering, and the other series uses clockwise steering. The maximum time permitted between each test run is five minutes.

- 5.6.1. From the slowly increasing steer tests, the quantity "A" is determined. "A" is the steering wheel angle in degrees that produces a steady state lateral acceleration (corrected using the methods specified in paragraph 5.11.3.) of 0.3g for the test vehicle. Utilizing linear regression, A is calculated, to the nearest 0.1 degrees, from each of the six slowly increasing steer tests. The absolute value of the six A values calculated is averaged and rounded to the nearest 0.1 degrees to produce the final quantity, A, used below.
- 5.7. After the quantity A has been determined, without replacing the tyres, the tyre conditioning procedure described in paragraph 5.5. is performed again immediately prior to conducting the Sine with Dwell test of paragraph 5.9. Initiation of the first Sine with Dwell test series shall begin within two hours after completion of the slowly increasing steer tests of paragraph 5.6.
- 5.8. Check that the ESC system is enabled by ensuring that the ESC malfunction and "ESC Off" (if provided) tell-tales are not illuminated.

5.9. Sine with Dwell test of oversteer intervention and responsiveness

The vehicle is subjected to two series of test runs using a steering pattern of a sine wave at 0.7 Hz frequency with a 500 ms delay beginning at the second peak amplitude as shown in Figure 2 (the Sine with Dwell tests). One series uses anticlockwise steering for the first half cycle, and the other series uses clockwise steering for the first half cycle. The vehicle is allowed to cool-down between each test runs for a period of 1.5 to 5 minutes, with the vehicle stationary.

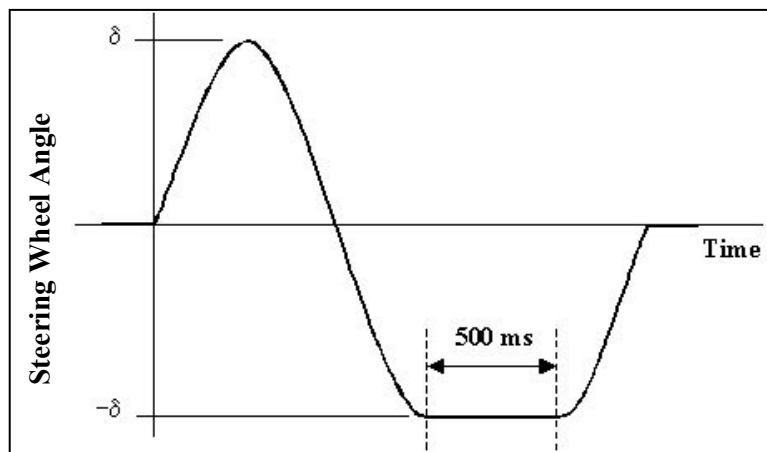


Figure 2. Sine with Dwell

- 5.9.1. The steering motion is initiated with the vehicle coasting in high gear at 80 ± 2 km/h.
- 5.9.2. The steering amplitude for the initial run of each series is 1.5 A, where A is the steering wheel angle determined in paragraph 5.6.1.
- 5.9.3. In each series of test runs, the steering amplitude is increased from run to run, by 0.5 A, provided that no such run will result in a steering amplitude greater than that of the final run specified in paragraph 5.9.4.
- 5.9.4. The steering amplitude of the final run in each series is the greater of 6.5 A or 270 degrees, provided the calculated magnitude of 6.5 A is less than or equal to 300 degrees. If any 0.5 A increment, up to 6.5 A, is greater than 300 degrees, the steering amplitude of the final run shall be 300 degrees.
- 5.9.5. Upon completion of the two series of test runs, post processing of yaw rate and lateral acceleration data is done as specified in paragraph 5.11.
- 5.10. ESC malfunction detection
- 5.10.1. Simulate one or more ESC malfunction(s) by disconnecting the power source to any ESC component, or disconnecting any electrical connection between ESC components (with the vehicle power off). When simulating an ESC malfunction, the electrical connections for the tell-tale lamp(s) and/or optional ESC system control(s) are not to be disconnected.
- 5.10.2. With the vehicle initially stationary and the ignition locking system in the "Lock" or "Off" position, switch the ignition locking system to the "Start" position and start the engine. Drive the vehicle forward to obtain a vehicle speed of 48 ± 8 km/h. 30 seconds, at the latest, after the engine has been started and within the next two minutes at this speed, conduct at least one left and one right smooth turning manoeuvre without losing directional

stability and one brake application. Verify that the ESC malfunction indicator illuminates in accordance with paragraph 3.4. by the end of these manoeuvres.

5.10.3. Stop the vehicle, switch the ignition locking system to the "Off" or "Lock" position. After a five-minute period, switch the vehicle's ignition locking system to the "Start" position and start the engine. Verify that the ESC malfunction indicator again illuminates to signal a malfunction and remains illuminated as long as the engine is running or until the fault is corrected.

5.10.4. Switch the ignition locking system to the "Off" or "Lock" position. Restore the ESC system to normal operation, switch the ignition system to the "Start" position and start the engine. Re-perform the manoeuvre described in paragraph 5.10.2. and verify that the tell-tale has extinguished within this time or immediately afterwards.

5.11. Post data processing – calculations for performance metrics

Yaw rate and lateral displacement measurements and calculations shall be processed utilizing the techniques specified in paragraphs 5.11.1. to 5.11.8.

5.11.1. Raw steering wheel angle data is filtered with a 12-pole phaseless Butterworth filter and a cut-off frequency of 10 Hz. The filtered data is then zeroed to remove sensor offset utilizing static pre-test data.

5.11.2. Raw yaw rate data is filtered with a 12-pole phaseless Butterworth filter and a cut-off frequency of 6 Hz. The filtered data is then zeroed to remove sensor offset utilizing static pre-test data.

5.11.3. Raw lateral acceleration data is filtered with a 12-pole phaseless Butterworth filter and a cut-off frequency of 6 Hz. The filtered data is then zeroed to remove sensor offset utilizing static pre-test data. The lateral acceleration data at the vehicle centre of gravity is determined by removing the effects caused by vehicle body roll and by correcting for sensor placement via the use of coordinate transformation. For data collection, the lateral accelerometer shall be located as close as possible to the position of the vehicle's longitudinal and lateral centres of gravity.

5.11.4. Steering wheel velocity is determined by differentiating the filtered steering wheel angle data. The steering wheel velocity data is then filtered with a moving 0.1 second running average filter.

5.11.5. Lateral acceleration, yaw rate and steering wheel angle data channels are zeroed utilizing a defined "zeroing range." The methods used to establish the zeroing range are defined in paragraphs 5.11.5.1. and 5.11.5.2.

5.11.5.1. Using the steering wheel rate data calculated using the methods described in paragraph 5.11.4., the first instant that the steering wheel rate exceeds 75 deg/sec is identified. From this point, steering wheel rate shall remain greater than 75 deg/sec for at least 200 ms. If the second condition is

not met, the next instant that the steering wheel rate exceeds 75 deg/sec is identified and the 200 ms validity check applied. This iterative process continues until both conditions are ultimately satisfied.

- 5.11.5.2. The "zeroing range" is defined as the 1.0 second time period prior to the instant the steering wheel rate exceeds 75 deg/sec (i.e., the instant the steering wheel velocity exceeds 75 deg/sec defines the end of the "zeroing range").
- 5.11.6. The Beginning of Steer (BOS) is defined as the first instance when the filtered and zeroed steering wheel angle data reaches -5 degrees (when the initial steering input is anticlockwise) or +5 degrees (when the initial steering input is clockwise) after a time defining the end of the "zeroing range." The value for time at the BOS is interpolated.
- 5.11.7. The Completion of Steer (COS) is defined as the time the steering wheel angle returns to zero at the completion of the Sine with Dwell steering manoeuvre. The value for time at the zero degree steering wheel angle is interpolated.
- 5.11.8. The second peak yaw rate is defined as the first local yaw rate peak produced by the reversal of the steering wheel. The yaw rates at 1.000 and 1.750 seconds after COS are determined by interpolation.
- 5.11.9. Determine lateral velocity by integrating corrected, filtered and zeroed lateral acceleration data. Zero lateral velocity at the BOS point. Determine lateral displacement by integrating zeroed lateral velocity. Zero lateral displacement at the BOS point. The lateral displacement measurement is made at 1.07 seconds after BOS point and is determined by interpolation.

B. REQUIREMENTS FOR BRAKE ASSIST SYSTEMS

1. GENERAL REQUIREMENTS

Every BAS system must comply with the definition of paragraph 0.16 of this appendix and shall meet the performance and test requirements contained in this appendix.

1.1. General performance characteristics for category "A" BAS systems

When an emergency condition has been sensed by a relative high pedal force, the additional pedal force to cause full cycling of the ABS shall be reduced compared to the pedal force required without the BAS system in operation.

Compliance with this requirement is demonstrated if the provisions of paragraphs 3.1. to 3.3. of this section are met.

1.2. General performance characteristics for category "B" BAS systems

When an emergency condition has been sensed, at least by a very fast application of the pedal, the BAS system shall raise the pressure to deliver the maximum achievable braking rate or cause full cycling of the ABS.

Compliance with this requirement is demonstrated if the provisions of paragraphs 4.1. to 4.3. of this section are met.

2. GENERAL TEST REQUIREMENTS

2.1. Variables

Whilst performing the tests described in part B of this appendix, the following variables shall be measured:

- 2.1.1. Brake pedal force, F_p ;
- 2.1.2. Vehicle velocity, v_x ;
- 2.1.3. Vehicle deceleration, a_x ;
- 2.1.4. Brake temperature, T_d ;
- 2.1.5. Brake pressure, P , where applicable;
- 2.1.6. Brake pedal speed, v_p , measured at the centre of the pedal plate or at a position on the pedal mechanism where the displacement is proportional to the displacement at the centre of the pedal plate allowing simple calibration of the measurement.

2.2. Measuring equipment

- 2.2.1. The variables listed in paragraph 2.1. of this section shall be measured by means of appropriate transducers. Accuracy, operating ranges, filtering techniques, data processing and other requirements are described in ISO Standard 15037-1: 2006.
- 2.2.2. Accuracy of pedal force and disc temperature measurements shall be as follows:

<i>Variable range system</i>	<i>Typical operating range of the transducers</i>	<i>Recommended maximum recording errors</i>
Pedal force	0 to 2,000 N	±10 N
Brake temperature	0 – 1,000 °C	±5 °C
Brake pressure*	0 – 20 MPa*	±100 kPa*

* Applicable as specified in paragraph 3.2.5.

- 2.2.3. Details on analogue and digital data processing of the BAS test procedures are described in Attachment 5 to this appendix. A sampling rate for data acquisition of at least 500 Hz is required.

- 2.2.4. Alternative measuring methods to those referred to in paragraph 2.2.3. may be allowed, provided they demonstrate at least an equivalent level of precision.
- 2.3. Test conditions
- 2.3.1. Test vehicle loading condition: The vehicle shall be unladen. There may be, in addition to the driver, a second person on the front seat who is responsible for noting the results of the tests.
- 2.3.2. Braking tests shall be carried out on a dry surface affording good adhesion.
- 2.4. Test method
- 2.4.1. The tests as described in paragraphs 3. and 4. of this section shall be carried out from a test speed of 100 ± 2 km/h. The vehicle shall be driven at the test speed in a straight line.
- 2.4.2. The average temperature of the brakes shall be in accordance with paragraph 2.4.2.1.
- 2.4.2.1. The average temperature of the service brakes on the hottest axle of the vehicle, measured inside the brake linings or on the braking path of the disc or drum, is between 65 and 100°C prior to any brake application.
- 2.4.3. For the tests the reference time, t_0 , is defined as the moment when the brake pedal force reaches 20 N.

Note: For vehicles equipped with a brake system assisted by an energy source, the applied pedal force necessary depends on the energy level that exists in the energy storage device. Therefore, sufficient energy level shall be ensured at the beginning of the test.

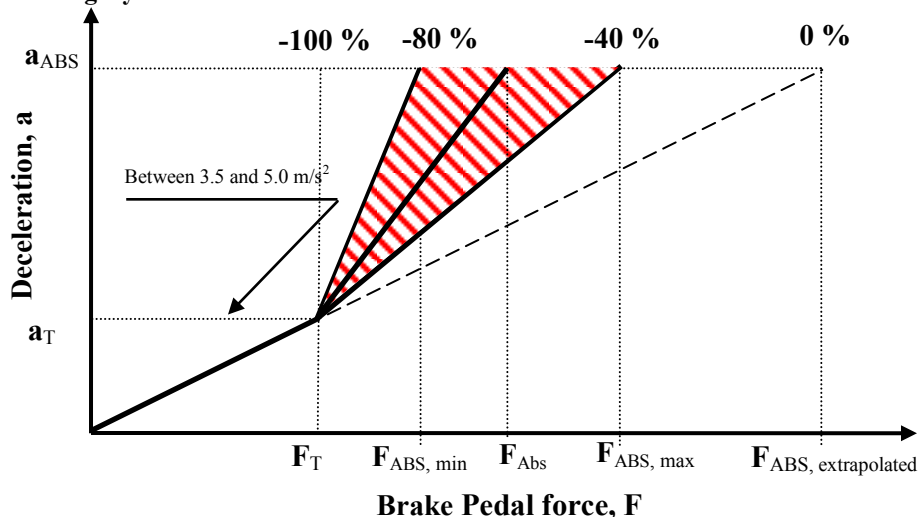
3. ASSESSMENT OF THE PRESENCE OF A CATEGORY "A" BAS

A category "A" BAS shall meet the test requirements contained in paragraphs 3.1. and 3.2.

- 3.1. Test 1: Reference test to determine F_{ABS} and a_{ABS} .
- 3.1.1. The reference values F_{ABS} and a_{ABS} shall be determined in accordance with the procedure described in Attachment 4 to this appendix.
- 3.2. Test 2: For activation of BAS
- 3.2.1. Once an emergency braking condition has been detected, systems sensitive to pedal force shall show a significant increase in the ratio of:
- (a) Brake line pressure to brake pedal force, where permitted by paragraph 3.2.5.; or
 - (b) Vehicle deceleration to brake pedal force.

- 3.2.2. The performance requirements for a category "A" BAS are met if a specific brake application characteristic can be defined that exhibits a decrease of between 40 per cent and 80 per cent in required brake pedal force for $(F_{ABS} - F_T)$ compared to $(F_{ABS, extrapolated} - F_T)$.
- 3.2.3. F_T and a_T are threshold force and threshold deceleration as shown in Figure 1. The values of F_T and a_T shall be supplied to the Technical Service or Test Facility. The value of a_T shall be between 3.5 m/s^2 and 5.0 m/s^2 .

Figure 1a
Pedal force characteristic needed in order to achieve maximum deceleration with category "A" BAS



- 3.2.4. A straight line is drawn from the origin through the point F_T, a_T (as shown in Figure 1a). The value of brake pedal force "F", at the point of intersection between this line and a horizontal line defined by $a=a_{ABS}$, is defined as $F_{ABS, extrapolated}$:

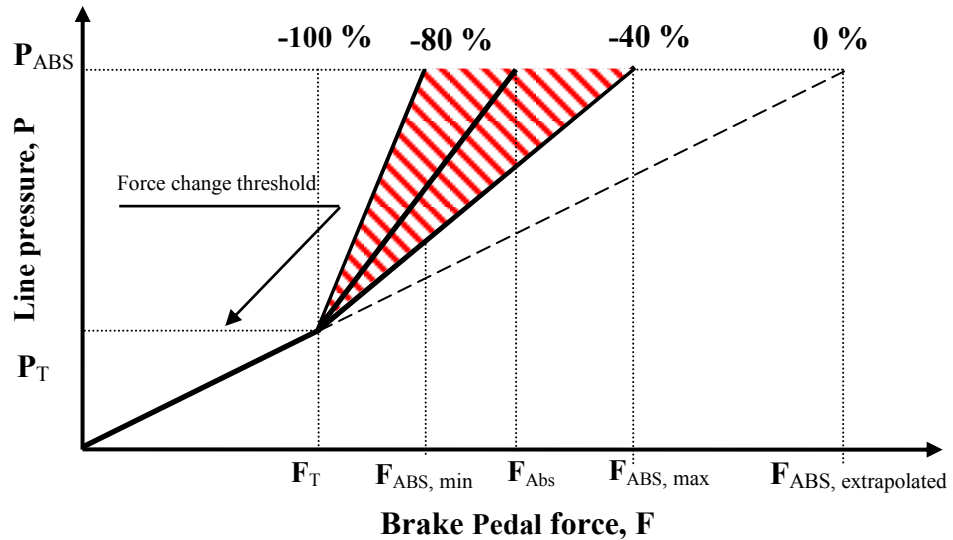
$$F_{ABS, extrapolated} = \frac{F_T \cdot a_{ABS}}{a_T}$$

- 3.2.5. As an alternative, which can be selected by the manufacturer, in the case of vehicles of category N_1 , or M_1 derived from those N_1 vehicles, with a gross vehicle mass $GVM > 2,500 \text{ kg}$, the pedal force figures for $F_T, F_{ABS, min}, F_{ABS, max}$ and $F_{ABS, extrapolated}$ may be derived from the brake line pressure response characteristic instead of the vehicle deceleration characteristic. This shall be measured as the brake pedal force is increasing.
 - 3.2.5.1. The pressure, at which ABS cycling commences, shall be determined by making five tests from $100 \pm 2 \text{ km/h}$ in which the brake pedal is applied up to the level which produces ABS operation and the five pressures at which this occurs as determined from front wheel pressure records, shall be recorded and the mean value obtained as P_{ABS} .
 - 3.2.5.2. The threshold pressure P_T shall be stated by the manufacturer and correspond to a deceleration in the range of $2.5 - 4.5 \text{ m/s}^2$.

3.2.5.3. Figure 1b shall be constructed in the manner set out in paragraph 3.2.4., but using line pressure measurements to define the parameters set out in paragraph 3.2.5. of this section where:

$$F_{ABS, \text{extrapolated}} = \frac{F_T \cdot P_{ABS}}{P_T}$$

Figure 1b
Pedal force characteristic needed in order to achieve maximum deceleration with category "A" BAS



3.3. Data evaluation

The presence of a category "A" BAS is proven if

$$F_{ABS, \text{min}} \leq F_{ABS} \leq F_{ABS, \text{max}}$$

where:

$$F_{ABS, \text{max}} - F_T \leq (F_{ABS, \text{extrapolated}} - F_T) \cdot 0.6$$

and

$$F_{ABS, \text{min}} - F_T \geq (F_{ABS, \text{extrapolated}} - F_T) \cdot 0.2$$

4. ASSESSMENT OF THE PRESENCE OF A CATEGORY "B" BAS

A category "B" BAS shall meet the test requirements contained within paragraphs 4.1. and 4.2. of this section.

4.1. Test 1: Reference test to determine F_ABS and a_ABS.

4.1.1. The reference values F_ABS and a_ABS shall be determined in accordance with the procedure described in Attachment 4 to this appendix.

4.2. Test 2: For activation of BAS

The vehicle shall be driven in a straight line at the test speed specified in paragraph 2.4. of this section. The driver shall apply the brake pedal quickly according to Figure 2, simulating emergency braking so that BAS is activated and ABS is fully cycling.

In order to activate BAS the brake pedal shall be applied as specified by the car manufacturer^{5/}. It shall be demonstrated that the BAS activates under these conditions.

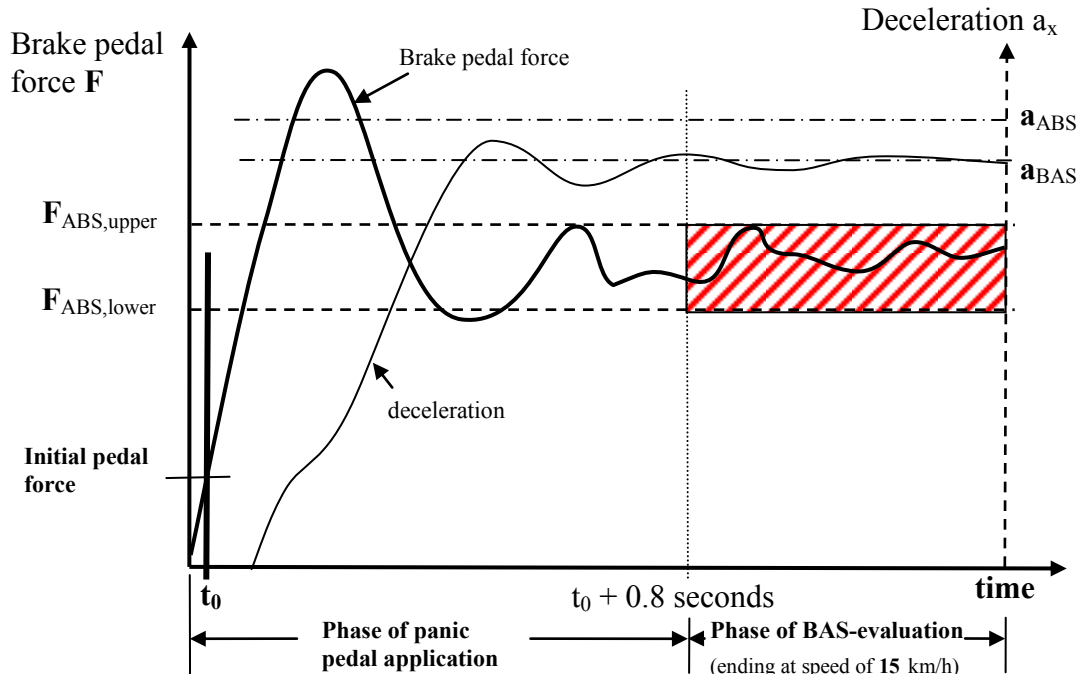
After $t = t_0 + 0.8$ s and until the vehicle has slowed down to a speed of 15 km/h, the brake pedal force shall be maintained in a corridor between $F_{ABS, upper}$ and $F_{ABS, lower}$, where $F_{ABS, upper}$ is $0.7 F_{ABS}$ and $F_{ABS, lower}$ is $0.5 F_{ABS}$.

The requirements are also considered to be met if, after $t = t_0 + 0.8$ s, the pedal force falls below $F_{ABS, lower}$ provided the requirement of paragraph 4.3. is fulfilled.

4.3. Data evaluation

The presence of BAS 'B' is demonstrated if a mean deceleration (a_{BAS}) of at least $0.85 \cdot a_{ABS}$ is maintained from the time when $t = t_0 + 0.8$ s to the time when the vehicle speed has been reduced to 15 km/h.

Figure 2
Example of test 2 of a category "B" BAS system



^{5/} The manufacturer shall define the brake pedal speed which must be achieved in order to activate the Brake Assist System (e.g. pedal stroke speed (mm/s) during a given time interval). (As per UN Regulation No. 13-H, Annex 1, paragraph 22.1.2.)

Appendix 2 - Attachment 1

The following is a modified form of Annex 9 – Appendix 1 of UNECE Regulation No. 13-H– UNIFORM PROVISIONS CONCERNING THE APPROVAL OF PASSENGER CARS WITH REGARD TO BRAKING, incorporating supplement 14 to the 00 series of amendments.

USE OF THE DYNAMIC STABILITY SIMULATION

The effectiveness of the electronic stability control system may be determined by computer simulation.

1. USE OF THE SIMULATION
 - 1.1. The vehicle stability function shall be able to be demonstrated by the vehicle manufacturer to the '*Administrator*' by simulating the dynamic manoeuvres of paragraph 5.9. of Appendix 2.
 - 1.2. The simulation shall be a means whereby the vehicle stability performance shall be demonstrated with:
 - (a) The yaw rate, one second after completion of the Sine with Dwell steering input (time $T_0 + 1$);
 - (b) The yaw rate, 1.75 seconds after completion of the Sine with Dwell steering input;
 - (c) The lateral displacement of the vehicle centre of gravity with respect to its initial straight path.
 - 1.3. The simulation shall be carried out with a validated modelling and simulation tool and using the dynamic manoeuvres of paragraph 5.9. of Appendix 2 under the test conditions of paragraph 4. of Appendix 2.

The method by which the simulation tool is validated is given in Attachment 2 to this appendix.

Appendix 2 - Attachment 2

The following is a modified form of Annex 9 – Appendix 2 of UNECE Regulation No. 13-H– UNIFORM PROVISIONS CONCERNING THE APPROVAL OF PASSENGER CARS WITH REGARD TO BRAKING, incorporating supplement 14 to the 00 series of amendments.

DYNAMIC STABILITY SIMULATION TOOL AND ITS VALIDATION

1. SPECIFICATION OF THE SIMULATION TOOL

- 1.1. The simulation method shall take into account the main factors which influence the directional and roll motion of the vehicle. A typical model may include the following vehicle parameters in an explicit or implicit form:
- (a) Axle/wheel
 - (b) Suspension
 - (c) Tyre
 - (d) Chassis/vehicle body
 - (e) Power train/driveline, if applicable
 - (f) Brake system
 - (g) Pay load
- 1.2. The Vehicle Stability Function shall be added to the simulation model by means of:
- a) A subsystem (software model) of the simulation tool; or
 - b) The electronic control box in a hardware-in-the-loop configuration.

2. VALIDATION OF THE SIMULATION TOOL

- 2.1. The validity of the applied modelling and simulation tool shall be verified by means of comparisons with practical vehicle tests. The tests utilised for the validation shall be the dynamic manoeuvres of paragraph 5.9. of Appendix 2.

During the tests, the following motion variables, as appropriate, shall be recorded or calculated in accordance with ISO 15037 Part 1:2005: General conditions for passenger cars or Part 2:2002: General conditions for heavy vehicles and buses (depending on the vehicle category):

- (a) Steering-wheel angle (δ_H)
- (b) Longitudinal velocity (v_X)
- (c) Sideslip angle (β) or lateral velocity (v_Y);(optional)
- (d) Longitudinal acceleration (a_X); (optional)
- (e) Lateral acceleration (a_Y)
- (f) Yaw velocity ($d\psi/dt$)
- (g) Roll velocity ($d\phi/dt$)
- (h) Pitch velocity ($d\theta/dt$)

- (i) Roll angle (φ)
- (j) Pitch angle (θ)

- 2.2. The objective is to show that the simulated vehicle behaviour and operation of the vehicle stability function is comparable with that seen in practical vehicle tests.
- 2.3. The simulator shall be deemed to be validated when its output is comparable to the practical test results produced by a given vehicle type during the dynamic manoeuvres of paragraph 5.9. of Appendix 2. The relationship of activation and sequence of the vehicle stability function in the simulation and in the practical vehicle test shall be the means of making the comparison.
- 2.4. The physical parameters that are different between the reference vehicle and simulated vehicle configurations shall be modified accordingly in the simulation.
- 2.5. A simulator test report shall be produced, a model of which is defined in Attachment 3 to this appendix, and a copy held by the manufacturer.

Appendix 2 - Attachment 3

The following is a modified form of Annex 9 – Appendix 3 of UNECE Regulation No. 13-H– UNIFORM PROVISIONS CONCERNING THE APPROVAL OF PASSENGER CARS WITH REGARD TO BRAKING, incorporating supplement 14 to the 00 series of amendments.

VEHICLE STABILITY FUNCTION SIMULATION TOOL TEST REPORT

Test Report Number:

1. Identification
 - 1.1. Name and address of the simulation tool manufacturer
 - 1.2. Simulation tool identification: name/model/number (hardware and software)
2. Scope of application
 - 2.1. Vehicle type:.....
 - 2.2. Vehicle configurations:
3. Verifying vehicle test
 - 3.1. Description of vehicle(s):
 - 3.1.1. Vehicle(s) identification: make/model/VIN
 - 3.1.2. Vehicle description, including suspension/wheels, engine and drive line, braking system(s), steering system, with name/model/number identification:.....
.....
 - 3.1.3. Vehicle data used in the simulation (explicit):.....
 - 3.2. Description of location(s), road/test area surface conditions, temperature and date(s):
 - 3.3. Results with the vehicle stability function switched on and off, including the motion variables referred to in Appendix 2, Attachment 2, paragraph 2.1. as appropriate:.....
.....
4. Simulation results

- 4.1. Vehicle parameters and the values used in the simulation that are not taken from the actual test vehicle (implicit):.....
- 4.2. Yaw stability and lateral displacement according to paragraphs 3.1. to 3.3. of Appendix 2:.....
- 5. This test has been carried out and the results reported in accordance with Appendix 2 - Attachment 2 to Australian Design Rule 35/05.

Technical Service conducting the test 1/

Signed:

Date:

1/ not used

- - - - -

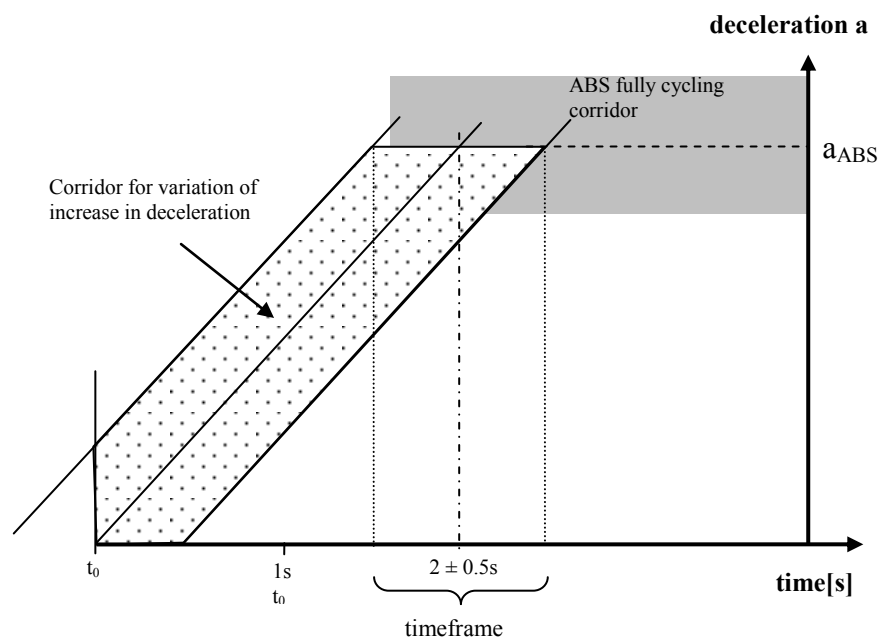
Appendix 2 - Attachment 4

The following is a modified form of Annex 9 – Appendix 4 of UNECE Regulation No. 13-H– UNIFORM PROVISIONS CONCERNING THE APPROVAL OF PASSENGER CARS WITH REGARD TO BRAKING, incorporating supplement 14 to the 00 series of amendments.

METHOD FOR DETERMINATION OF F_{ABS} AND a_{ABS}

- 1.1. The brake pedal force F_{ABS} is the minimum pedal force that has to be applied for a given vehicle in order to achieve maximum deceleration which indicates that ABS is fully cycling. a_{ABS} is the deceleration for a given vehicle during ABS deceleration as defined in paragraph 1.7.
- 1.2. The brake pedal shall be applied slowly (without activating the BAS in the case of category B systems) providing a constant increase of deceleration until ABS is fully cycling (Figure 3).
- 1.3. The full deceleration must be reached within the timeframe of 2.0 ± 0.5 s. The deceleration curve, recorded against time, must be within a corridor of ± 0.5 s around the centre line of the deceleration curve corridor. The example in Figure 3 has its origin at the time t_0 crossing the a_{ABS} line 2 seconds. Once full deceleration has been achieved, the brake pedal shall be operated so that the ABS continues fully cycling. The time of full activation of the ABS system is defined as the time when pedal force F_{ABS} is achieved. The measurement shall be within the corridor for variation of increase in deceleration (see Figure 3).

Figure 3
Deceleration corridor for determination of F_{ABS} and a_{ABS}



- 1.4. Five tests meeting the requirements of paragraph 1.3. shall be carried out. For each of these valid tests the vehicle deceleration shall be plotted as a function of the recorded brake pedal force. Only data recorded at speeds above 15 km/h shall be taken for the calculations described in the following paragraphs.
- 1.5. For the determination of a_{ABS} and F_{ABS} , a low pass filter of 2 Hz for vehicle deceleration as well as pedal force shall be applied.
- 1.6. The five individual "deceleration versus brake pedal force" curves are averaged by calculating the mean deceleration of the five individual "deceleration vs. brake pedal force" curves at increments of 1 N pedal force. The result is the mean deceleration versus brake pedal force curve, which will be referred to as the "maF curve" in this appendix.
- 1.7. The maximum value for the vehicle deceleration is determined from the "maF curve" and is named as " a_{max} ".
- 1.8. All values of the "maF curve" that are above 90 per cent of this deceleration value " a_{max} " are averaged. This value of "a" is the deceleration " a_{ABS} " referred to in this appendix.
- 1.9. The minimum force on the pedal (F_{ABS}) sufficient to achieve the deceleration a_{ABS} is defined as the value of F corresponding to $a = a_{ABS}$ on the maF curve.

Appendix 2 - Attachment 5

The following is a modified form of Annex 9 – Appendix 5 of UNECE Regulation No. 13-H– UNIFORM PROVISIONS CONCERNING THE APPROVAL OF PASSENGER CARS WITH REGARD TO BRAKING, incorporating supplement 14 to the 00 series of amendments.

DATA PROCESSING FOR THE BAS

(see paragraph 2.2.3. of section B of this appendix)

1. Analogue data processing

The bandwidth of the entire, combined transducer/recording system shall be no less than 30 Hz.

In order to execute the necessary filtering of signals, low-pass filters with order 4 or higher shall be employed. The width of the pass band (from 0 Hz to frequency f_0 at -3 dB) shall not be less than 30 Hz. Amplitude errors shall be less than ± 0.5 per cent in the relevant frequency range of 0 Hz to 30 Hz. All analogue signals shall be processed with filters having sufficiently similar phase characteristics to ensure that time delay differences due to filtering lie within the required accuracy for time measurement.

Note: During analogue filtering of signals with different frequency contents, phase shifts can occur. Therefore, a data processing method, as described in paragraph 2. of this attachment, is preferable.

2. Digital data processing

2.1. General consideration

Preparation of analogue signals includes consideration of filter amplitude attenuation and sampling rate to avoid aliasing errors, and filter phase lags and time delays. Sampling and digitising considerations include pre-sampling amplification of signals to minimize digitising errors; number of bits per sample; number of samples per cycle; sample and hold amplifiers; and time-wise spacing of samples. Considerations for additional phaseless digital filtering include selection of pass bands and stop bands and the attenuation and allowable ripple in each; and correction of filter phase lags. Each of these factors shall be considered in order to achieve a relative overall data acquisition accuracy of ± 0.5 per cent.

2.2. Aliasing errors

In order to avoid uncorrectable aliasing errors, the analogue signals shall be appropriately filtered before sampling and digitising. The order of the filters used and their pass band shall be chosen according to both the required flatness in the relevant frequency range and the sampling rate.

The minimum filter characteristics and sampling rate shall be such that:

- (a) Within the relevant frequency range of 0 Hz to $f_{\max} = 30$ Hz the attenuation is less than the resolution of the data acquisition system; and
- (b) At one-half the sampling rate (i.e. the Nyquist or "folding" frequency) the magnitudes of all frequency components of signal and noise are reduced to less than the system resolution.

For 0.05 per cent resolution the filter attenuation shall be less than 0.05 per cent in the frequency range between 0 and 30 Hz, and the attenuation shall be greater than 99.95 per cent at all frequencies greater than one-half the sampling frequency.

Note: For a Butterworth filter the attenuation is given by:

$$A^2 = \frac{1}{1 + \left(\frac{f_{\max}}{f_0}\right)^{2n}} \quad \text{and} \quad A^2 = \frac{1}{1 + \left(\frac{f_N}{f_0}\right)^{2n}}$$

where:

n is the order to filter;

f_{\max} is the relevant frequency range (30 Hz);

f_0 is the filter cut-off frequency;

f_N is the Nyquist or "folding" frequency.

For a fourth order filter

for $A = 0.9995$: $f_0 = 2.37 \cdot f_{\max}$

for $A = 0.0005$: $f_s = 2 \cdot (6.69 \cdot f_0)$, where f_s is the sampling frequency $= 2 \cdot f_N$.

2.3. Filter phase shifts and time delays for anti-aliasing filtering

Excessive analogue filtering shall be avoided, and all filters shall have sufficiently similar phase characteristics to ensure that time delay differences are within the required accuracy for the time measurement. Phase shifts are especially significant when measured variables are multiplied together to form new variables, because while amplitudes multiply, phase shifts and associated time delays add. Phase shifts and time delays are reduced by increasing f_0 . Whenever equations describing the pre-sampling filters are known, it is practical to remove their phase shifts and time delays by simple algorithms performed in the frequency domain.

Note: In the frequency range in which the filter amplitude characteristics remain flat, the phase shift Φ of a Butterworth filter can be approximated by

$\Phi = 81 \cdot (f/f_0)$ degrees for second order

$\Phi = 150 \cdot (f/f_0)$ degrees for fourth order

$\Phi = 294 \cdot (f/f_0)$ degrees for eighth order

The time delay for all filter orders is: $t = (\Phi/360) \cdot (1/f_0)$

2.4. Data sampling and digitising

At 30 Hz the signal amplitude changes by up to 18 per cent per millisecond. To limit dynamic errors caused by changing analogue inputs to 0.1 per cent, sampling or digitising time shall be less than 32 μ s. All pairs or sets of data samples to be compared shall be taken simultaneously or over a sufficiently short time period.

2.5. System requirements

The data system shall have a resolution of 12 bits (± 0.05 per cent) or more and an accuracy of ± 0.1 per cent (2 lbs). Anti-aliasing filters shall be of order 4 or higher and the relevant data range f_{\max} shall be 0 Hz to 30 Hz.

For fourth order filters the pass-band frequency f_0 (from 0 Hz to frequency f_0) shall be greater than $2.37 \cdot f_{\max}$ if phase errors are subsequently adjusted in digital data processing, and greater than $5 \cdot f_{\max}$ otherwise. For fourth order filters the data sampling frequency f_s shall be greater than $13.4 \cdot f_0$.

Appendix 2 - Attachment 6

The following is a modified form of Annex 8 of UNECE Regulation No. 13-H- UNIFORM PROVISIONS CONCERNING THE APPROVAL OF PASSENGER CARS WITH REGARD TO BRAKING, incorporating supplement 14 to the 00 series of amendments.

SPECIAL REQUIREMENTS TO BE APPLIED TO THE SAFETY ASPECTS OF COMPLEX ELECTRONIC VEHICLE CONTROL SYSTEMS

1. GENERAL

This attachment defines the special requirements for documentation, fault strategy and verification with respect to the safety aspects of Complex Electronic Vehicle Control Systems (definition 2.3. below) as far as this standard is concerned.

This attachment does not specify the performance criteria for "The System" but covers the methodology applied to the design process and the information which shall be able to be provided by the vehicle manufacturer to the *'Administrator'*.

This information shall show that "The System" respects, under normal and fault conditions, all the appropriate performance requirements specified elsewhere in this standard.

2. DEFINITIONS

For the purposes of this attachment,

- 2.1. "Safety concept" is a description of the measures designed into the system, for example within the electronic units, so as to address system integrity and thereby ensure safe operation even in the event of an electrical failure.

The possibility of a fall-back to partial operation or even to a back-up system for vital vehicle functions may be a part of the safety concept.

- 2.2. "Electronic control system" means a combination of units, designed to co-operate in the production of the stated vehicle control function by electronic data processing.

Such systems, often controlled by software, are built from discrete functional components such as sensors, electronic control units and actuators and connected by transmission links. They may include mechanical, electro-pneumatic or electro-hydraulic elements.

"The System", referred to herein, is the one for which type approval is being sought.

- 2.3. "Complex electronic vehicle control systems" are those electronic control systems which are subject to a hierarchy of control in which a controlled function may be over-ridden by a higher level electronic control system/function.

A function which is over-ridden becomes part of the complex system.

- 2.4. "Higher-level control" systems/functions are those which employ additional processing and/or sensing provisions to modify vehicle behaviour by commanding variations in the normal function(s) of the vehicle control system.

This allows complex systems to automatically change their objectives with a priority which depends on the sensed circumstances.

- 2.5. "Units" are the smallest divisions of system components which will be considered in this annex, since these combinations of components will be treated as single entities for purposes of identification, analysis or replacement.

- 2.6. "Transmission links" are the means used for inter-connecting distributed units for the purpose of conveying signals, operating data or an energy supply.

This equipment is generally electrical but may, in some part, be mechanical, pneumatic, hydraulic or optical.

- 2.7. "Range of control" refers to an output variable and defines the range over which the system is likely to exercise control.

- 2.8. "Boundary of functional operation" defines the boundaries of the external physical limits within which the system is able to maintain control.

3. DOCUMENTATION

3.1. Requirements

The manufacturer shall maintain a documentation package which gives access to the basic design of "The System" and the means by which it is linked to other vehicle systems or by which it directly controls output variables.

The function(s) of "The System" and the safety concept, as laid down by the manufacturer, shall be explained.

Documentation shall be brief, yet provide evidence that the design and development has had the benefit of expertise from all the system fields which are involved.

For periodic technical inspections, the documentation shall describe how the current operational status of "The System" can be checked.

3.1.1. Documentation shall be made available in 2 parts:

- (a) The formal documentation package, containing the material listed in Section 3 (with the exception of that of paragraph 3.4.4.) which shall be able to be supplied to the 'Administrator' upon request. This will be taken as the basic reference for the verification process set out in paragraph 4. of this attachment.
- (b) Additional material and analysis data of paragraph 3.4.4., which shall be retained by the manufacturer.

3.2. Description of the functions of "The System"

A description shall be provided which gives a simple explanation of all the control functions of "The System" and the methods employed to achieve the objectives, including a statement of the mechanism(s) by which control is exercised.

3.2.1. A list of all input and sensed variables shall be provided and the working range of these defined.

3.2.2. A list of all output variables which are controlled by "The System" shall be provided and an indication given, in each case, of whether the control is direct or via another vehicle system. The range of control (paragraph 2.7.) exercised on each such variable shall be defined.

3.2.3. Limits defining the boundaries of functional operation (paragraph 2.8.) shall be stated where appropriate to system performance.

3.3. System layout and schematics

3.3.1. Inventory of components

A list shall be provided, collating all the units of "The System" and mentioning the other vehicle systems which are needed to achieve the control function in question.

An outline schematic showing these units in combination, shall be provided with both the equipment distribution and the interconnections made clear.

3.3.2. Functions of the units

The function of each unit of "The System" shall be outlined and the signals linking it with other Units or with other vehicle systems shall be shown.

This may be provided by a labelled block diagram or other schematic, or by a description aided by such a diagram.

3.3.3. Interconnections

Interconnections within "The System" shall be shown by a circuit diagram for the electrical transmission links, by an optical-fiber diagram for optical links, by a piping diagram for pneumatic or hydraulic transmission equipment and by a simplified diagrammatic layout for mechanical linkages.

3.3.4. Signal flow and priorities

There shall be a clear correspondence between these transmission links and the signals carried between units.

Priorities of signals on multiplexed data paths shall be stated, wherever priority may be an issue affecting performance or safety as far as this standard is concerned.

3.3.5. Identification of units

Each unit shall be clearly and unambiguously identifiable (e.g. by marking for hardware and marking or software output for software content) to provide corresponding hardware and documentation association.

Where functions are combined within a single unit or indeed within a single computer, but shown in multiple blocks in the block diagram for clarity and ease of explanation, only a single hardware identification marking shall be used.

The manufacturer shall, by the use of this identification, affirm that the equipment supplied conforms to the corresponding document.

3.3.5.1. The identification defines the hardware and software version and, where the latter changes such as to alter the function of the unit as far as this Regulation is concerned, this identification shall also be changed.

3.4. Safety concept of the manufacturer

3.4.1. The manufacturer shall provide a statement which affirms that the strategy chosen to achieve "The System" objectives will not, under non-fault conditions, prejudice the safe operation of systems which are subject to the prescriptions of this Regulation.

3.4.2. In respect of software employed in "The System", the outline architecture shall be explained and the design methods and tools used shall be identified. The manufacturer shall be prepared, if required, to show some

evidence of the means by which they determined the realisation of the system logic, during the design and development process.

- 3.4.3. The manufacturer shall provide an explanation of the design provisions built into "The System" so as to generate safe operation under fault conditions. Possible design provisions for failure in "The System" are for example:
- (a) Fall-back to operation using a partial system.
 - (b) Change-over to a separate back-up system.
 - (c) Removal of the high level function.

In case of a failure, the driver shall be warned for example by warning signal or message display. When the system is not deactivated by the driver, e.g. by turning the Ignition (run) switch to "off", or by switching off that particular function if a special switch is provided for that purpose, the warning shall be present as long as the fault condition persists.

- 3.4.3.1. If the chosen provision selects a partial performance mode of operation under certain fault conditions, then these conditions shall be stated and the resulting limits of effectiveness defined.

- 3.4.3.2. If the chosen provision selects a second (back-up) means to realise the vehicle control system objective, the principles of the change-over mechanism, the logic and level of redundancy and any built in back-up checking features shall be explained and the resulting limits of back-up effectiveness defined.

- 3.4.3.3. If the chosen provision selects the removal of the higher level function, all the corresponding output control signals associated with this function shall be inhibited, and in such a manner as to limit the transition disturbance.

- 3.4.4. The documentation shall be supported, by an analysis which shows, in overall terms, how the system will behave on the occurrence of any one of those specified faults which will have a bearing on vehicle control performance or safety.

This may be based on a Failure Mode and Effect Analysis (FMEA), a Fault Tree Analysis (FTA) or any similar process appropriate to system safety considerations.

The chosen analytical approach(es) shall be established and recorded by the manufacturer.

- 3.4.4.1. This documentation shall itemise the parameters being monitored and shall set out, for each fault condition of the type defined in paragraph 3.4.4. above, the warning signal to be given to the driver and/or to service/technical inspection personnel.

4. VERIFICATION AND TEST

4.1. The functional operation of "The System", as laid out in the documents required in paragraph 3., shall be tested as follows:

4.1.1. Verification of the function of "The System"

As the means of establishing the normal operational levels, verification of the performance of the vehicle system under non-fault conditions shall be conducted against the manufacturer's basic benchmark specification unless this is subject to a specified performance test as part of the approval procedure of this or another standard.

4.1.2. Verification of the safety concept of paragraph 3.4.

The reaction of "The System" shall, at the discretion of the type approval authority, be checked under the influence of a failure in any individual unit by applying corresponding output signals to electrical units or mechanical elements in order to simulate the effects of internal faults within the unit.

4.1.2.1. The verification results shall correspond with the documented summary of the failure analysis, to a level of overall effect such that the safety concept and execution are confirmed as being adequate.

Appendix 2 - Attachment 7

The following is a modified form of Appendix 2 to Annex 6 of UNECE Regulation No. 13-H– UNIFORM PROVISIONS CONCERNING THE APPROVAL OF PASSENGER CARS WITH REGARD TO BRAKING, incorporating supplement 14 to the 00 series of amendments.

UTILIZATION OF ADHESION

1. METHOD OF MEASUREMENT

1.1. Determination of the coefficient of adhesion (k)

1.1.1. The coefficient of adhesion (k) shall be determined as the quotient of the maximum braking forces without locking the wheels and the corresponding dynamic load on the axle being braked.

1.1.2. The brakes shall be applied on only one axle of the vehicle under test, at an initial speed of 50 km/h. The braking forces shall be distributed between the wheels of the axle to reach maximum performance. The anti-lock system shall be disconnected, or inoperative, between 40 km/h and 20 km/h.

1.1.3. A number of tests at increments of line pressure shall be carried out to determine the maximum braking rate of the vehicle (z_{\max}). During each test, a constant input force shall be maintained and the braking rate will be determined by reference to the time taken (t) for the speed to reduce from 40 km/h to 20 km/h using the formula:

$$z = \frac{0.566}{t}$$

z_{\max} is the maximum value of z; t is in seconds.

1.1.3.1. Wheel lock may occur below 20 km/h.

1.1.3.2. Starting from the minimum measured value of t, called t_{\min} , then select three values of t comprised within t_{\min} and $1.05 t_{\min}$ and calculate their arithmetical mean value t_m ,

then calculate:
$$z_m = \frac{0.566}{t_m}$$

If it is demonstrated that for practical reasons the three values defined above cannot be obtained, then the minimum time t_{\min} may be utilized. However, the requirements of paragraph 1.3. shall still apply.

- 1.1.4. The braking forces shall be calculated from the measured braking rate and the rolling resistance of the unbraked axle which is equal to 0.015 and 0.010 of the static axle load for a driven axle and a non-driven axle, respectively.
- 1.1.5. The dynamic load on the axle shall be that given by the denominator in the formulae shown in paragraph 1.1.8. below;
- 1.1.6. The value of k shall be rounded to three decimal places.
- 1.1.7. Then, the test will be repeated for the other axle(s) as defined in paragraphs 1.1.1. to 1.1.6. above.
- 1.1.8. For example, in the case of a two-axle rear-wheel drive vehicle, with the front axle (1) being braked, the coefficient of adhesion (k) is given by:

$$k_f = \frac{z_m \cdot P \cdot g - 0.015F_2}{F_1 + \frac{h}{E} \cdot z_m \cdot P \cdot g}$$

The other symbols (P, h, E) are defined below;

- i = axle index (i = 1, front axle;
i = 2, rear axle)
- g = acceleration due to gravity : g = 9.81 m/s²
- P = mass of vehicle
- h = height of centre of gravity specified by the manufacturer and agreed by the Technical Services conducting the approval test
- E = wheelbase

- 1.1.9. One coefficient will be determined for the front axle k_f and one for the rear axle k_r .