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Subject:	ANNEXES to the Commission Delegated Regulation (EU) No .../.. of XXX supplementing Regulation (EU) No 167/2013 of the European Parliament and of the Council with regard to vehicle braking requirements for the approval of agricultural and forestry vehicles

Delegations will find attached document C(2014) 7410 final - ANNEXES 1-7.

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ANNEXES 1 to 7

ANNEXES

to the

Commission Delegated Regulation (EU) No .../..
of XXX

supplementing Regulation (EU) No 167/2013 of the European Parliament and of the Council with regard to vehicle braking requirements for the approval of agricultural and forestry vehicles

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ANNEX I

Requirements applying to construction and fitting of braking devices and trailer braking couplings

1. Definitions

For the purposes of this Annex:

1.1. ‘coupling force control’ means a system or function to balance automatically the braking rate of tractor and towed vehicle;

1.2. ‘nominal demand value’ means a characteristic of coupling force control that relates the coupling head signal to the braking rate and which can be demonstrated at type-approval, within the limits of the compatibility bands of Appendix 1 of Annex II;

1.3. ‘track rollers’ means the system that transmits the weight of the vehicle and crawler undercarriage to the ground via the track belt, transmits torque from the vehicle’s drive system to the track belt and may produce a change of direction of the moving belt;

1.4. ‘crawler undercarriage’ means a system comprising at least two track rollers, which are spaced a specified distance apart in one plane (in-line) and a continuous metallic or rubber track belt that runs around them;

1.5. ‘track belt’ means a continuous flexible belt, which can absorb longitudinal tractive forces.

2. Construction and fitting requirements

2.1. General

The maximum design speed is considered, throughout this Annex, to be in the forward direction of the vehicle travel, unless otherwise explicitly mentioned.

2.1.1. Braking components, separate technical units and parts

2.1.1.1. The braking components, separate technical units and parts shall be so designed, constructed and fitted as to enable the vehicle in normal use, despite the vibration to which it may be subjected, to comply with the under mentioned requirements.

2.1.1.2. In particular, the braking components, separate technical units and parts shall be so designed, constructed and fitted as to be able to resist the corrosion and ageing phenomena to which it is exposed.

2.1.1.3. Brake linings shall not contain asbestos.

2.1.1.4. It is not permitted to fit any components, separate technical units and parts (such as valves) that would allow the performance of the braking system to be changed by the user of the

vehicle such that, in service, it falls outside the requirements of this Regulation. A component, separate technical unit and part that can only be operated by the manufacturer through the use of special tool or the provision of a tamper proof seal or both shall be permitted provided that the user of the vehicle is not able to modify this component, separate technical unit and part or that any user modification is readily identifiable by enforcement authorities.

2.1.1.5. A towed vehicle shall be equipped with an automatic load sensing device, with the exception of the following cases:

2.1.1.5.1. If a towed vehicle with a maximum design speed not exceeding 30 km/h cannot be equipped for technical reasons with an automatic load sensing device, it may be equipped with a device having at least three discrete settings for the control of the braking forces.

2.1.1.5.2. In the special case that a towed vehicle allows by design that only two discrete loading conditions 'unladen' and 'laden' can be realized then the vehicle may have only two discrete settings for the control of the braking forces.

2.1.1.5.3. S-category vehicles the machinery of which does not contain any other load including consumable material.

2.1.2. Functions of the braking system

The braking system shall fulfil the following functions:

2.1.2.1. Service braking system

It shall be possible to graduate the service braking system action. The driver shall be able to achieve this braking action from his driving position without removing his hands from the steering control device.

2.1.2.2. Secondary braking system

The secondary braking system shall make it possible to halt the vehicle within a reasonable distance in the event of the failure of the service braking system. On tractors, it shall be possible to graduate this braking action. The driver shall be able to obtain this braking action from his driving seat while keeping at least one hand on the steering control device. For the purpose of these requirements, it is assumed that not more than one failure of the service braking system can occur at one time.

2.1.2.3. Parking braking system

The parking braking system shall enable the vehicle to be held stationary on an up or down gradient even in the absence of the driver, the working parts of the braking system being then held in the locked position by a purely mechanical device. The driver shall be able to achieve this braking action from his driving seat, subject, in the case of a towed vehicle, to the requirements of point 2.2.2.11.

The towed vehicle service braking system (pneumatic or hydraulic) and the parking braking system of the tractor may be operated simultaneously, provided that the driver is able to check, at any time, that the parking braking system performance of the vehicle

combination, obtained by the purely mechanical action of the parking braking system, is sufficient.

2.1.3. The relevant requirements of Appendix 1 of Annex II shall be applied to vehicles and their braking systems.

2.1.4. Connections, for compressed-air braking systems, between tractors and towed vehicles

2.1.4.1. The connections of the compressed-air braking systems between tractors and towed vehicles shall be provided according to the following points 2.1.4.1.1., 2.1.4.1.2. or 2.1.4.1.3.

2.1.4.1.1. one pneumatic supply line and one pneumatic control line;

2.1.4.1.2. one pneumatic supply line, one pneumatic control line and one electric control line;

2.1.4.1.3. one pneumatic supply line and one electric control line. Until uniform technical standards have been agreed, which ensure compatibility and safety, connections between tractors and trailers conforming to the provisions of this point shall not be permitted.

2.1.5. Connections between tractors and towed vehicles with hydraulic braking systems

2.1.5.1. Type of connections

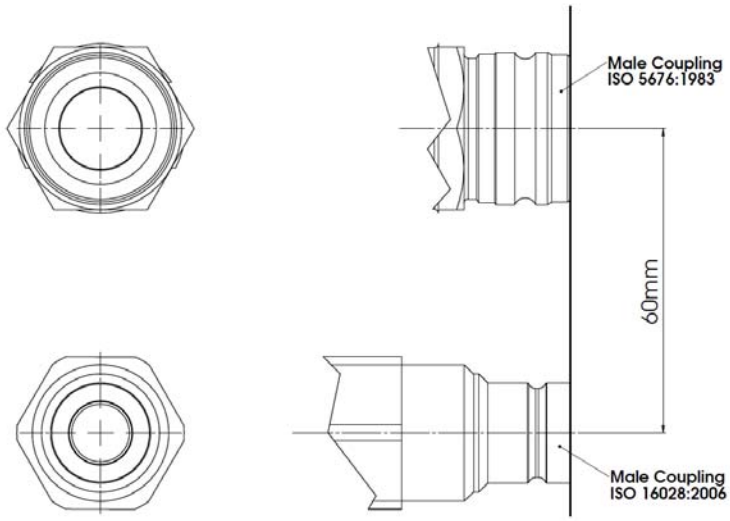
2.1.5.1.1. Hydraulic control line: this is the connecting line with the male connector on the tractor and the female connector on the towed vehicle. The connectors shall comply with ISO 5676:1983.

2.1.5.1.2. Hydraulic supplementary line: this is the connecting line with the male connector on the tractor and the female connector on the towed vehicle. The connectors shall comply with ISO 16028:2006, size 10.

2.1.5.1.3. ISO 7638:2003 connector (optional). The ISO 7638:2003 connector may be used for 5 pin or 7 pin applications, as appropriate.

The positioning of the connectors as specified in points 2.1.5.1.1. and 2.1.5.1.2. shall be arranged on the tractor as illustrated in Figure 1.

Figure 1: Hydraulic connecting lines



2.1.5.2. With the engine running and the parking braking system of the tractor fully applied:

2.1.5.2.1. a pressure of 0^{+100} kPa is present on the supplementary line and/or

2.1.5.2.2. a pressure between 11,500 kPa and 15,000 kPa is generated on the control line.

2.1.5.3. With the engine running and the parking braking system of the tractor fully released a pressure between the values provided at point 2.2.1.18.3. shall be present on the supplementary line.

2.1.5.4. With the engine running and no brake control on the tractor applied (driving or stand-by condition), the pressure supplied at the coupling head of the control line shall be the one provided at point 2.2.1.18.2.

2.1.5.5. With the engine running and the service brake control device on the tractor fully actuated a pressure between 11,500 kPa and 15,000 kPa shall be generated in the control line. For pressurizing the control line during service brake application the tractor shall be capable to comply with requirement of point 3.6. of Annex III.

2.1.6. The flexible hoses and cables connecting tractors and towed vehicles shall be a part of the towed vehicle.

2.1.7. Shut-off devices which are not automatically actuated shall not be permitted.

2.1.8. Pressure test connections

2.1.8.1. For the purpose of determining the in-use braking forces of each axle of the vehicle, with a compressed-air braking system, air pressure test connections must be provided:

2.1.8.1.1. In each independent circuit of the braking system, at the closest readily accessible position to the brake cylinder which is the least favourably placed as far as the response time described in Annex III is concerned.

2.1.8.1.2. In a braking system which incorporates a device that modulates the air or hydraulic pressure in the brake transmission as referred to in point 6.2. of Appendix I to Annex II, located in the pressure line upstream and downstream of this device at the closest accessible position. If this device is pneumatically controlled an additional test connection is required to simulate the laden condition. Where no such device is fitted, a single pressure test connection, equivalent to the downstream connector mentioned above, shall be provided. These test connections shall be so located as to be easily accessible from the ground or within the vehicle.

2.1.8.1.3. At the closest readily accessible position to the least favourably placed energy storage device within the meaning of point 2.4. of section A of Annex IV.

2.1.8.1.4. In each independent circuit of the braking system so it is possible to check the input and output pressure of the complete transmission line.

2.1.8.1.5. The pressure test connections shall comply with clause 4 of ISO Standard 3583:1984.

2.2. Requirements of braking systems

2.2.1. Vehicles of categories T and C

2.2.1.1. The set of braking systems with which a vehicle is equipped shall satisfy the requirements laid down for the service, secondary and parking braking systems.

In order to assist the driver in steering (to enable differential braking in the field) the service braking system of the tractor may consist of two independent brake circuits, each connected to one separate right or left brake pedal.

If the differential braking function is activated it shall not be possible to travel at speeds exceeding 40 km/h or at speeds in excess of 40 km/h the differential braking function shall be disabled. These two operations shall be ensured by automatic means.

If the differential mode is activated an actuation of the towed vehicle service braking system is not required up to a speed of 12 km/h.

In tractors where the separate pedals can be connected manually, the driver shall be able to easily verify from his driving place whether these pedals are connected or not.

2.2.1.2. The equipment providing service, secondary and parking braking may have common components, provided that they fulfil the following conditions:

2.2.1.2.1. There shall be at least two controls, each corresponding to a different braking system, independent of each other and readily accessible to the driver from his normal driving position. For all categories of vehicles, every brake control device (excluding endurance braking system control device) shall be designed in a way that it returns to the fully-off position when released. This requirement shall not apply to a parking braking system control device (or that part of a combined control device) when it is mechanically locked in an applied position or it is utilised for the secondary braking or in both cases.

2.2.1.2.2. The control device of the service braking system shall be independent of the control device of the parking braking system.

2.2.1.2.3. Where the service and secondary braking systems have the same control device, the effectiveness of the linkage between that control device and the various components of the transmission systems shall not be liable to deteriorate after a certain period of use.

2.2.1.2.4. Where the service and secondary braking systems have the same control device, the parking braking system shall be so designed that it can be actuated when the vehicle

is in motion. This requirement shall not apply if the vehicle's service braking system can be actuated, even partially, by means of an auxiliary control.

2.2.1.2.5. In the event of a breakage of any component other than the brakes or the components specified in point 2.2.1.2.7. , or of any other failure of the service braking system (malfunction, partial or total exhaustion of an energy reserve), the secondary braking system or that part of the service braking system which is not affected by the failure shall be able to bring the vehicle to a halt in the conditions prescribed for secondary braking.

2.2.1.2.6. In particular, where the secondary braking system and the service braking system have a common control device and common transmission:

2.2.1.2.6.1. where the service braking system is actuated by the muscular energy of the driver assisted by one or more energy reserves, the secondary braking performance shall, in the event of failure of that assistance, be capable of being ensured by the muscular energy of the driver assisted by the energy reserves, if any, which are unaffected by the failure, the force applied to the control device not exceeding the prescribed maxima.

2.2.1.2.6.2. If the service braking force and transmission depend exclusively on the use, controlled by the driver, of an energy reserve, there shall be at least two completely independent energy reserves, each provided with its own transmission likewise independent; each of them may act on the brakes of only two or more wheels so selected as to be capable of ensuring by themselves the prescribed degree of secondary braking without endangering the stability of the vehicle during braking; in addition, each of the those energy reserves shall be equipped with a warning device. In at least one of the air reservoirs of each service braking circuit a device for draining and exhausting is required in an adequate and easily accessible position.

2.2.1.2.6.3. If the service braking force and transmission depend exclusively on the use of an energy reserve, one energy reserve for the transmission is deemed to be sufficient, provided that the prescribed secondary braking is ensured by the action of the driver's muscular energy acting on the service brake control device and the requirements of point 2.2.1.5. are met.

2.2.1.2.7. Certain parts, such as the pedal and its bearing, the master cylinder and its piston(s) (hydraulic systems), the control valve (hydraulic or pneumatic systems), the linkage between the pedal and the master cylinder or the control valve, the brake cylinders and their pistons (hydraulic or pneumatic systems), and the lever-and-cam assemblies of brakes, shall not be regarded as liable to breakage if they are amply dimensioned, are readily accessible for maintenance, and exhibit safety features at least equal to those prescribed for other essential components (such as the steering linkage) of the vehicle. Where the failure of any such part would make it impossible to brake the vehicle with a performance at least equal to that prescribed for the secondary braking system that part shall be made of metal or of a material with equivalent characteristics and shall not be subject to significant distortion in the normal operation of the braking systems.

2.2.1.3. Where there are separate control devices for the service and secondary braking systems simultaneous actuation of control devices shall not render both the service and secondary

braking systems inoperative, either when both braking systems are in good working order or when one of them is faulty.

2.2.1.4. Where use is made of energy other than the muscular energy of the driver, there need not be more than one source of such energy (hydraulic pump, air compressor, etc.), but the means by which the device constituting that source is driven shall be as safe as practicable.

2.2.1.4.1. In the event of failure in any part of the transmission of a vehicle's braking system consisting of two service braking circuits fulfilling the requirements of point 2.2.1.25., the supply to the part not affected by the failure shall continue to be ensured where this is required for the purpose of halting the vehicle with the degree of effectiveness prescribed for residual and/or for secondary braking. This condition shall be satisfied by automatic means.

2.2.1.4.2. Furthermore, storage devices located down-circuit of this device are such that in the event of a failure in the energy supply, after four full-stroke actuations of the service braking system control device under the testing conditions prescribed in point 1.2 of section A or in point 1.2 of section B or in point 1.2 of section C of Annex IV, following to the kind of braking system, it is still possible to halt the vehicle at the fifth application with the degree of effectiveness prescribed for secondary braking.

2.2.1.4.3. For hydraulic braking systems with stored energy, requirements of points 2.2.1.4.1. and 2.2.1.4.2. shall be considered to be met, provided that the requirements of point 1.2.2. of Part C of Annex IV to this Regulation, are satisfied.

2.2.1.4.4. In the case of a service braking system consisting of only one service braking circuit it is required that in the event of a failure or non-availability of the energy source it shall be possible halting the vehicle with the service braking system control with the degree of effectiveness prescribed for secondary braking.

2.2.1.5. The requirements of points 2.2.1.2., 2.2.1.4. and 2.2.1.25. shall be satisfied without the use of any automatic device of a kind such that its ineffectiveness might pass unnoticed because the parts which are normally in an 'at rest' position are actuated only in the event of failure of the braking system.

2.2.1.6. On vehicles with a maximum design speed not exceeding 30 km/h, the service braking system shall act on all the wheels of at least one axle. In all other cases the service braking system shall act on all the wheels of the vehicle. However, in case of vehicles with one braked axle and an automatic engagement of the drive to all other axles during braking, all wheels are deemed to be braked.

For category C vehicles this condition is considered to be met if all of the track rollers of the vehicle are braked. For category C vehicles with a design speed of less than 30 km/h, this condition is considered to be met if at least one track roller on each side of the vehicle is braked.

For vehicles equipped with a straddle seat and handlebars, the service braking may act either on the front axle or on the rear axle provided that all the performance requirements prescribed in point 2 of Annex II to this Regulation are met.

For articulated tractors of category Ta, if an axle is subject to braking and the differential is mounted between the service brake and the wheels, all wheels of that axle are deemed to

be braked when the activation of the service braking system automatically locks the differential on this axle.

2.2.1.6.1. Performance of hydraulic lines and hose assemblies in case of vehicles with one braked axle and an automatic engagement of the drive to all other axles during braking

The hydraulic lines of hydraulic transmission shall be capable of a burst pressure at least four times the maximum normal service pressure (T) specified by the vehicle manufacturer. Hose assemblies shall comply with ISO Standards 1402:1994, 6605:1986 and 7751: 1991.

2.2.1.7. If the service braking system acts on all wheels or track rollers of the vehicle, the action shall be appropriately distributed among the axles. Where this is achieved by means of a device which modulates the pressure in the brake transmission, this shall conform to the requirements of point 6 of Appendix 1 to Annex II and point 2.1.8.

2.2.1.7.1. In the case of vehicles with more than two axles, in order to avoid wheel-locking or glazing of the brake linings, the brake force on certain axles may be reduced to zero automatically when carrying a much reduced load, provided that the vehicle meets all the performance requirements prescribed in Annex II.

2.2.1.8. The action of the service braking system shall be distributed between the wheels or track rollers of the same axle symmetrically in relation to the longitudinal median plane of the vehicle.

2.2.1.9. The service, secondary and the parking braking systems shall act on braking surfaces permanently connected to the wheels through components of adequate strength. It shall not be possible to disconnect a braking surface from the wheels; however, such disconnection shall be permitted in the case of the parking braking system, provided that it is controlled exclusively by the driver from his driving seat by a system which cannot be actuated by a leak. When more than one axle is normally subject to braking in the case of vehicles of categories T and C with a maximum design speed not exceeding 60 km/h, one axle may be decoupled provided that activation of the service braking system automatically re-couples this axle and that, in the case of a failure in the energy supply or a failure in the control transmission of the re-coupling control device, then automatic re-coupling shall be ensured.

2.2.1.10. It shall be possible for the wear of the service brakes to be compensated by means of a system of manual adjustment. For vehicles of categories Tb and Cb, the wear of the service brakes shall be compensated by means of a system of automatic adjustment. In addition, the control device and the components of the transmission and of the brakes shall possess a reserve of travel and, if necessary, suitable means of compensation such that, when the brakes become heated or when the brake linings have reached a certain degree of wear, effective braking shall be ensured without immediate adjustment being necessary.

Vehicles of categories Ta, and category Ca, do not need to be fitted with a system where the wear of the brakes are compensated by means of a system of automatic adjustment. However, if vehicles of these categories are equipped with system where the wear of the brakes are compensated by means of a system of automatic adjustment, this system shall comply with the same requirements as those of category Tb and Cb.

2.2.1.10.1. Automatic wear adjustment devices, if fitted, shall, after heating followed by cooling, be capable of free running as laid down in point 2.3.4. of Annex II following the Type-I test also specified in point 1.3. of that Annex.

It shall be possible to easily check this wear on service brake linings from the outside or underside of the vehicle, utilising only the tools or equipment normally supplied with the vehicle; for instance, by the provision of appropriate inspection holes or by some other means. Alternatively, acoustical or optical devices warning the driver at his driving position when lining replacement is necessary are acceptable.

2.2.1.10.2. The requirements of 2.2.1.10. and 2.2.1.10.1. are not applicable to oil immersed brakes which are designed for the whole lifetime of the vehicle without servicing.

2.2.1.11. In hydraulic braking systems:

2.2.1.11.1. The filling ports of the fluid reservoirs shall be readily accessible; in addition, the containers of reserve fluid shall be so made that the level of the reserve fluid can be easily checked without the containers having to be opened. Where this last condition is not fulfilled, the red warning signal specified in point 2.2.1.29.1.1. shall draw the driver's attention to any fall in the level of reserve fluid liable to cause a failure of the braking system.

2.2.1.11.2. A failure in the hydraulic transmission where the prescribed service braking performance cannot be obtained shall be signalled to the driver by a device comprising a warning signal, as specified in point 2.2.1.29.1.1. Alternatively, the lighting up of this device when the fluid in the reservoir is below a certain level specified by the manufacturer shall be permitted.

2.2.1.11.3. The type of fluid to be used in the hydraulic transmission of braking systems shall be identified by the symbol in accordance with Figure 1 or 2 of Standard ISO 9128:2006. The symbol shall be affixed within 100 mm of the filling ports of the fluid reservoirs, in accordance with the requirements laid down on the basis of Article 17 (2) (k) and (5) of Regulation (EU) 167/2013. Additional information may be provided by the manufacturers. This requirement only applies to vehicles having a separate filling port for the fluid of the braking system.

2.2.1.12. Warning device

2.2.1.12.1. Any vehicle fitted with a service braking system actuated by an energy reservoir shall, where the prescribed secondary braking performance cannot be obtained by means of this braking system without the use of stored energy, be provided with a warning device - in addition to a pressure gauge where fitted - giving an optical or acoustic signal when the stored energy in any part of the system falls to a value at which, without recharging of the reservoir and irrespective of the loading conditions of the vehicle, it shall be possible to apply the service braking system control device a fifth time after four full-stroke actuations and obtain the prescribed secondary braking performance (without faults in the service-brake transmission and with the brakes adjusted as closely as possible). The warning device shall be directly and permanently connected to the circuit. When the engine is running under normal operating conditions and there are no faults in the braking system, the warning

device shall give no signal except during the time required for charging the energy reservoir(s) after start-up of the engine.

2.2.1.12.1.1. However, in the case of vehicles which are only considered to comply with the requirements of point 2.2.1.4.1. by virtue of meeting the requirements of point 1.2.2. of section C of Annex IV the alarm device shall consist of an acoustic signal in addition to an optical signal. These devices need not operate simultaneously, provided that each of them meets the above requirements and the acoustic signal is not actuated before the optical signal.

2.2.1.12.2. This acoustic device may be rendered inoperative while the parking braking system is applied or, at the choice of the manufacturer, in the case of automatic transmission the selector in the 'park' position or in both cases.

2.2.1.13. Without prejudice to the requirements of point 2.1.2.3., where the use of an auxiliary energy source is essential for the operation of a braking system, the energy reserve shall be such as to ensure that, should the engine stop, or in the event of a failure of the means by which the energy source is driven, the braking performance remains sufficient to bring the vehicle to a halt in the prescribed conditions. In addition, if the muscular energy applied by the driver to the parking braking system is reinforced by some aid, the actuation of the parking braking system shall be ensured in the event of failure of that aid, if necessary by using a reserve of energy independent of that normally supplying such aid. This reserve of energy may be that intended for the service braking system.

2.2.1.14. In the case of a tractor to which the coupling of a towed vehicle equipped with a brake controlled by the driver of the tractor is authorised, the service braking system of the tractor shall be fitted with a device so designed that if the towed vehicle braking system should fail, or the supply line (or such other type of connection as may be adopted) between the tractor and towed vehicle should break, it will still be possible to brake the tractor with the performance prescribed for the secondary braking system; it is accordingly prescribed, in particular, that this device be fitted to the tractor service braking system ensuring that the tractor can still be braked by the service braking system with a performance prescribed for the secondary braking system.

2.2.1.15. The pneumatic or hydraulic auxiliary equipment shall be automatically supplied with energy in such a way that during its operation the prescribed performance values can be reached and that even in the event of damage to the source of energy, the operation of the auxiliary equipment cannot cause the reserves of energy feeding the braking systems to fall below the level indicated in point 2.2.1.12.

2.2.1.16. A tractor authorised to tow a category R2, R3, R4 or S2 vehicle shall satisfy the following conditions:

2.2.1.16.1. When the service braking system of the tractor is actuated there shall also be a graduated braking action on the towed vehicle, see also point 2.2.1.18.4.

2.2.1.16.2. When the tractor's secondary braking system comes into action, there shall also be a braking action in the towed vehicle. In the case of tractors of categories Tb and Cb this braking action shall be graduable.

2.2.1.16.3. Should the service braking system of the tractor fail, and if this system is made up of at least two independent sections, the section or sections not affected by this failure shall be able to fully or partially actuate the towed vehicle brakes. This requirement does not apply where the two independent sections consist in one section braking left hand wheels and one section braking right hand wheels, such a design aiming at permitting differential braking for cornering in the fields. Should in the latter case, the service braking system of the tractor fail, then the secondary braking system shall be able to fully or partially actuate the towed vehicle brakes. If this operation is achieved by a valve which is normally at rest, then such a valve may only be incorporated if its correct functioning can easily be checked by the driver, either from within the cab or from outside the vehicle, without the use of tools.

2.2.1.17. Additional requirements in the case of tractors authorised to draw towed vehicles with compressed-air braking systems.

2.2.1.17.1. In the event of a failure (e.g. breakage) in one of the pneumatic connecting lines, interruption or defect in the electric control line, it shall nevertheless be possible for the driver, fully or partially, to actuate the brakes of the towed vehicle by means either of the service braking control device or of the secondary braking control device or of the parking braking control device, unless the failure automatically causes the towed vehicle to be braked with the performance prescribed in point 3.2.3. of Annex II.

2.2.1.17.2. The automatic braking in point 2.2.1.17.1. shall be considered to be met when the following conditions are fulfilled:

2.2.1.17.2.1. When the designated brake control device of the ones mentioned in point 2.2.1.17.1., is fully actuated, the pressure in the supply line shall fall to 150 kPa within the following two seconds; in addition, when the brake control device is released, the supply line shall be re-pressurized.

2.2.1.17.2.2. When the supply line is evacuated at the rate of at least 100 kPa per second the automatic braking of the towed vehicle shall start to operate before the pressure in the supply line falls to 200 kPa.

2.2.1.17.3. In the event of a failure in one of the control lines connecting two vehicles equipped according to point 2.1.4.1.2. , the control line not affected by the failure shall automatically ensure the braking performance prescribed for the towed vehicle in point 3.2.3. of Annex II.

2.2.1.17.4. In the case of a pneumatic service braking system comprising two or more independent sections, any leakage between those sections at or downstream of the control device shall be continuously vented to atmosphere.

2.2.1.18. Additional requirements in the case of tractors authorised to draw towed vehicles with hydraulic braking systems.

2.2.1.18.1. The pressure supplied at both coupling heads with the engine not running shall always be 0 kPa.

2.2.1.18.2. The pressure supplied at the coupling head of the control line with the engine running and no braking control force applied shall be 0^{+200} kPa.

2.2.1.18.3. With the engine running it shall be possible to generate at the coupling head of the supplementary line a pressure of at least 1,500 kPa but not exceeding 3,500 kPa

2.2.1.18.4. As a derogation from the requirement of point 2.2.1.16.1. , a graduated braking action on the towed vehicle is only required when the service braking system of the tractor is actuated when the engine is running.

2.2.1.18.5. In the case of a failure (e.g. fracture or leak) in the supplementary line, it shall nevertheless be possible for the driver to fully or partially actuate the towed vehicle brakes, by means either of the service braking system control device or of the parking braking system control device, unless this failure automatically causes the towed vehicle to be braked with the performance prescribed in point 3.2.3. of Annex II.

2.2.1.18.6. In the case of a failure (e.g. fracture or leak) in the control line, the pressure in the supplementary line shall fall to 1,000 kPa within the following two seconds after the service brake control device has been fully actuated; in addition, when the service brake control device is released, the supplementary line shall be re-pressurized (see also point 2.2.2.15.3.).

2.2.1.18.7. The pressure in the supplementary line shall fall from its maximum value to 0^{+300} kPa within the following second after the parking braking system control device has been fully actuated.

In order to check the evacuation time the supplementary line of the towed vehicle simulator according to point 3.6.2.1. of Annex III is connected to the supplementary line of the tractor.

The accumulators of the simulator are then charged to the maximum value generated by the tractor with the engine running and the bleeding device (point 1.1. of Appendix 2 of Annex III) fully closed.

2.2.1.18.8. In order to be able to connect and disconnect the hydraulic connecting lines even when the engine is running and the parking braking system applied, an appropriate device may be fitted on the tractor.

This device shall be so designed and constructed that the pressure in the connecting lines is positively restored to the rest position not later than the control (e.g. push button) of this device is automatically released (e.g. valve returns automatically into the normal operation position).

2.2.1.18.9. Tractors towing a vehicle of category R or S and which can only comply with the braking performance requirements of the service braking system and/or parking braking system and/or automatic braking system with the assistance of energy stored in a hydraulic energy storage device shall be equipped with an ISO 7638:2003

connector in order to be able to indicate the low level of stored energy on the towed vehicle, received by the latter, as laid down in point 2.2.2.15.1.1. by the separate warning signal via pin 5 of the electrical connector conforming to ISO 7638:2003 specified in point 2.2.1.29.2.2. (see also point 2.2.2.15.1.). The ISO 7638:2003 connector may be used for 5 pin or 7 pin applications, as appropriate.

2.2.1.19. In the case of a tractor authorized to tow a vehicle of categories R3, R4 or S2, the service braking system of the towed vehicle may only be operated in conjunction with the service, secondary or parking braking system of the tractor. However, automatic application of the towed vehicle brakes alone is permitted where the operation of the towed vehicle brakes is initiated automatically by the tractor for the sole purpose of vehicle stabilization.

2.2.1.19.1. By way of derogation from point 2.2.1.19., in order to improve the driving behaviour of the vehicle combination by modifying the coupling force between the tractor and towed vehicle, it is permissible that towed vehicle brakes are applied automatically up to a time of 5 s without the operation of the service, secondary or parking braking system of the tractor.

2.2.1.20. If point 3.1.3. of Annex II can only be fulfilled by complying with the conditions specified in point 3.1.3.4.1.1. of Annex II then

2.2.1.20.1. in the case of compressed-air braking system, a control line pressure (or the equivalent digital demand) of at least 650 kPa shall be transmitted when a single control device is fully activated which also applies the tractor parking braking system. This shall also be ensured when the ignition/start switch has been switched off and/or the key has been removed;

2.2.1.20.2. in the case of hydraulic braking system, when a single control device is fully activated a pressure of 0^{+100} kPa shall be generated on the supplementary line.

2.2.1.21. Anti-lock braking systems for tractors of category Tb

2.2.1.21.1. Tractors of category Tb with a maximum design speed exceeding 60 km/h shall be equipped with anti-lock braking systems of category 1 in accordance with the requirements of Annex XI.

2.2.1.21.2. Tractors of category Tb with a maximum design speed exceeding 40 km/h and not exceeding 60 km/h shall be equipped with anti-lock braking systems of category 1 in accordance with the requirements of Annex XI

(a) for new vehicle types as from 1 January 2020 and

(b) for new vehicles as from 1 January 2021.

2.2.1.22. Tractors authorized to tow a vehicle equipped with an anti-lock braking system shall also be equipped with a special electrical connector, conforming to ISO 7638:2003, for the electric control transmission. The ISO 7638:2003 connector may be used for 5 pin or 7 pin applications, as appropriate.

2.2.1.23. If tractors not mentioned in points 2.2.1.21.1. and 2.2.1.21.2. are fitted with anti-lock braking systems, they shall comply with the requirements of Annex XI.

2.2.1.24. The requirements of Annex X shall be applied to the safety aspects of all complex electronic vehicle control systems which provide or form part of the control transmission of the braking function included those which utilize the braking system(s) for automatically commanded braking or selective braking.

2.2.1.25. In the case of category Tb tractors with a maximum design speed exceeding 60 km/h, the service braking system shall, whether or not it is combined with the secondary braking system, be such that in the event of failure in a part of its transmission a sufficient number of wheels are still braked by actuation of the service brake control device; these wheels shall be so selected that the residual performance of the service braking system satisfies the requirements laid down in point 3.1.4. of Annex II.

The part or parts not affected by the failure shall be capable of partially or fully actuating the brakes of the towed vehicle.

2.2.1.25.1. The failure of a part of a hydraulic transmission system shall be signalled to the driver by a device comprising a warning signal, as specified in point 2.2.1.29.1.1. Alternatively, the lighting up of this device when the fluid in the reservoir is below a certain level specified by the manufacturer shall be permitted.

2.2.1.26. Special additional requirements for the electric transmission of the parking braking system

2.2.1.26.1. Tractors with a maximum design speed exceeding 60 km/h

2.2.1.26.1.1. In the case of a failure within the electric transmission, any unintended actuation of the parking braking system shall be prevented.

2.2.1.26.1.2. In the case of an electrical failure in the control or a break in the wiring within the electric control transmission external to the electronic control unit(s), excluding the energy supply, it shall remain possible to apply the parking braking system from the driver's seat and thereby be capable of holding the laden vehicle stationary on an 8% up or down gradient.

2.2.1.26.2. Tractors with a maximum design speed not exceeding 60 km/h

2.2.1.26.2.1. In the case of an electrical failure in the control or a break in the wiring within the electric control transmission external to the control unit(s), excluding the energy supply,

2.2.1.26.2.1.1. any unintended actuation of the parking braking system at a vehicle speed above 10 km/h shall be prevented;

2.2.1.26.2.1.2. it shall remain possible to apply the parking braking system from the driver's seat and thereby be capable of holding the laden vehicle stationary on an 8% up or down gradient.

2.2.1.26.3. Alternatively to the parking brake performance requirements according to points 2.2.1.26.1.2. and 2.2.1.26.2.1. an automatic actuation of the parking braking system is allowed when the vehicle is stationary, provided that the above performance is achieved and, once applied, the parking braking system remains engaged independently of the status of the ignition (start) switch. In this alternative, the

parking braking system shall be automatically released as soon as the driver starts to set the vehicle in motion again.

2.2.1.26.4. It shall also be possible to release the parking braking system, if necessary by the use of tools and/or an auxiliary device carried/fitted on the vehicle.

2.2.1.26.5. A break in the wiring within the electric transmission, or an electric failure in the control device of the parking braking system shall be signalled to the driver by the yellow warning signal specified in point 2.2.1.29.1.2. When caused by a break in the wiring within the electric control transmission of the parking braking system, this yellow warning signal shall be signalled as soon as the break occurs or in the case of tractors with a maximum design speed not exceeding 60 km/h not later than on actuation of the relevant braking control. In addition, such an electric failure in the control device or break in the wiring external to the electronic control unit(s) and excluding the energy supply shall be signalled to the driver by flashing the warning signal specified in point 2.2.1.29.1.1. as long as the ignition (start) switch is in the "on" (run) position including a period of not less than 10 seconds thereafter and the control device is in the "on" (activated) position.

However, if the parking braking system detects correct clamping of the parking braking system, the flashing of the warning signal may be suppressed and the non-flashing red signal shall be used to indicate parking braking system applied.

Where actuation of the parking braking system is normally indicated by a separate warning signal, satisfying all the requirements of 2.2.1.29.3. this signal shall be used to satisfy the above requirement for a red signal.

2.2.1.26.6. Auxiliary equipment may be supplied with energy from the electric transmission of the parking braking system provided that the supply of energy is sufficient to allow the actuation of the parking braking system in addition to the vehicle electrical load under non-fault conditions. In addition, where the energy reserve is also used by the service braking system, the requirements of point 4.1.7. of Annex XII shall apply.

2.2.1.26.7. After the ignition/start switch which controls the electrical energy for the braking equipment has been switched off and/or the key removed, it shall remain possible to apply the parking braking system, whereas releasing shall be prevented.

Releasing of the parking braking system is permitted if the control has to be mechanically unlocked in order to be able to release the parking braking system.

2.2.1.27. The requirements of Annex XII shall be applied with regard to EBS vehicles or vehicles with ‘data communication’ via pin 6 and 7 of ISO 7638 connector.

2.2.1.28. Special requirements for coupling force control

2.2.1.28.1. Coupling force control is only permitted in the tractor.

2.2.1.28.2. The action of the coupling force control shall be to reduce the difference between the dynamic braking rates of tractors and towed vehicles. The operation of the coupling force control shall be checked at the time of type-approval. The method by which this check is carried out shall be agreed between the vehicle manufacturer and the

technical service with the method of assessment and results being appended to the type-approval report.

2.2.1.28.2.1. The coupling force control may control the braking rate TM/FM (point 2 of Appendix 1 to Annex II) and/or the brake demand value(s) for the towed vehicle. In the case of a tractor equipped with two control lines according to point 2.1.4.1.2. of this Annex, both signals shall be subject to similar control adjustments.

2.2.1.28.2.2. The coupling force control shall not prevent the maximum possible braking pressure(s) from being applied.

2.2.1.28.3. The vehicle shall fulfil the laden compatibility requirements of Appendix 1 to Annex II, but to achieve the objectives of point 2.2.1.28.2. the vehicle may deviate from these requirements when the coupling force control is in operation.

2.2.1.28.4. A coupling force control failure shall be detected and indicated to the driver by a yellow warning signal such as that specified in point 2.2.1.29.1.2. In the event of a failure the relevant requirements of Appendix 1 to Annex II shall be fulfilled.

2.2.1.28.5. Compensation by the coupling force control system shall be indicated by means of the yellow warning signal specified in point 2.2.1.29.1.2. if this compensation exceeds 150 kPa (pneumatic) and 2,600 kPa (hydraulic) respectively away from the nominal demand value up to a limit, in pm, of 650 kPa (or the equivalent digital demand) and 11,500 kPa (hydraulic) respectively. Above the level of 650 kPa and 11,500 kPa (hydraulic) respectively the warning shall be given if the compensation causes the operating point to lie outside the laden compatibility band as specified in Appendix 1 to Annex II, for tractors.

2.2.1.28.6. A coupling force control system shall control only the coupling forces generated by the service braking system of the tractor and the towed vehicle. Coupling forces resulting from the performance of endurance braking systems shall not be compensated by the service braking system of either the tractor or towed vehicle. It is considered that endurance braking systems are not part of the service braking systems.

2.2.1.29. Brake failure and defect warning signal

The requirements for optical warning signals, whose function is to indicate to the driver certain specified failures or defects within the braking equipment of the tractor or of the towed vehicle, are set out in the points 2.2.1.29.1 – 2.2.1.29.6.3. The function of these signals shall be exclusively to indicate failures or defects in the braking equipment. However, the optical warning signal described in point 2.2.1.29.6. may in addition be used to indicate failures or defects in the running gear.

2.2.1.29.1. Tractors shall be capable of providing optical brake failure and defect warning signals, as follows:

2.2.1.29.1.1. A red warning signal, in accordance with the requirements laid down on the basis of Article 18 (2) (l), (s), (q) and (4) of Regulation (EU) No 167/2013 indicating failures within the vehicle braking equipment, as specified in other points of this Annex and in Annexes V, VII, IX and XIII, which preclude achievement of the prescribed service braking performance or the functioning of at least one of two independent service braking circuits.

2.2.1.29.1.2. Where applicable, a yellow warning signal, in accordance with the requirements laid down on the basis of Article 18 (2) (l), (s), (q) and (4) of Regulation (EU) No 167/2013 indicating an electrically detected defect within the vehicle braking equipment, which is not indicated by the warning signal mentioned in point 2.2.1.29.1.1. above.

2.2.1.29.2. Tractors equipped with an electric control line and/or authorized to tow a vehicle equipped with an electric control transmission, shall be capable of providing a separate warning signal, in accordance with the requirements laid down on the basis of Article 18 (2) (l), (s), (q) and (4) of Regulation (EU) No 167/2013 to indicate a defect within the electric control transmission of the braking equipment of the towed vehicle. The signal shall be activated from the towed vehicle via pin 5 of the electric connector conforming to ISO 7638:2003 and in all cases the signal transmitted by the towed vehicle shall be displayed without significant delay or modification by the tractor. This warning signal shall not light up when coupled to a towed vehicle without an electric control line and/or electric control transmission or when no towed vehicle is coupled. This function shall be automatic.

2.2.1.29.2.1. In the case of a tractor equipped with an electric control line, when electrically connected to a towed vehicle with an electric control line, the warning signal specified in point 2.2.1.29.1.1. shall also be used to indicate certain specified failures within the braking equipment of the towed vehicle, whenever the towed vehicle provides corresponding failure information via the data communication part of the electric control line. This indication shall be in addition to the warning signal specified in point 2.2.1.29.2. Alternatively, instead of utilizing the warning signal specified in point 2.2.1.29.1.1. and the accompanying warning signal above, a separate warning signal, in accordance with the requirements laid down on the basis of Article 18 (2) (l), (s), (q) and (4) of Regulation (EU) No 167/2013 may be provided in the tractor to indicate such a failure within the braking equipment of the towed vehicle.

2.2.1.29.2.2. Tractors equipped with an electric connector conforming to ISO 7638:2003 in order to be able to indicate the low level of stored energy on the towed vehicle as required by points 2.2.2.15.1.1. and 2.2.2.15.2. shall display the separate yellow warning signal mentioned in point 2.2.1.29.2. to the driver when the warning signal is transmitted to the tractor by the towed vehicle via pin 5 of the electric connector conforming to ISO 7638:2003.

2.2.1.29.3. Except where stated otherwise:

2.2.1.29.3.1. a specified failure or defect shall be signalled to the driver by the above-mentioned warning signal(s) not later than on actuation of the relevant braking control device;

2.2.1.29.3.2. the warning signal(s) shall remain displayed as long as the failure or defect persists and the ignition (start) switch is in the “on” (run) position;

2.2.1.29.3.3. the warning signal shall be constant (not flashing).

2.2.1.29.4. The warning signals shall be visible, even by daylight; the satisfactory condition of the signals shall be easily verifiable by the driver from the driver's seat; the failure of a component of the warning devices shall not entail any loss of the braking system's performance.

2.2.1.29.5. The warning signal(s) mentioned above shall light up when the electrical equipment of the vehicle (and the braking system) is energized. With the vehicle stationary, the braking system shall verify that none of the specified failures or defects are present before extinguishing the signals. Specified failures or defects which should activate the warning signals mentioned above, but which are not detected under static conditions, shall be stored upon detection and be displayed at start-up and at all times when the ignition (start) switch is in the “on” (run) position, as long as the failure or defect persists.

2.2.1.29.6. Non-specified failures or defects or other information concerning the brakes or running gear of the tractor, may be indicated by the signal specified in point 2.2.1.29.1.2. , provided that all the following conditions are fulfilled:

2.2.1.29.6.1. the vehicle is stationary;

2.2.1.29.6.2. after the braking system is first energised and the signal has indicated that, following the procedures detailed in point 2.2.1.29.5. , no specified failures (or defects) have been identified; and

2.2.1.29.6.3. non-specified faults or other information shall be indicated only by the flashing of the warning signal. However, the warning signal shall be extinguished by the time when the vehicle first exceeds 10 km/h.

2.2.1.30. Malfunctions of the electric control transmission shall not apply the brakes contrary to the driver's intentions.

2.2.1.31. Tractors fitted with hydrostatic drive shall either comply with all relevant requirements of this Annex or of Annex IX.

2.2.2. Vehicles of categories R and S

2.2.2.1. Vehicles of categories R1a, R1b (where the sum of the technically permissible masses per axle does not exceed 750kg), S1a, S1b (where the sum of the technically permissible masses per axle does not exceed 750kg) do not need to be fitted with a service braking system. However, if vehicles of these categories are equipped with a service braking system, this system shall comply with the same requirements as those of category R2 or S2 as appropriate.

2.2.2.2. Vehicles of categories R1b and S1b (where the sum of the technically permitted masses per axle exceeds 750 kg) and R2 shall be fitted with a service braking system either of the continuous or semi-continuous type or of the inertia type. However, if the vehicles of these categories have a service braking system of the continuous or semi-continuous type they shall meet the same requirements as those of category R3.

2.2.2.3. Where a towed vehicle belongs to category R3, R4 or S2, the service braking system shall be of a continuous or semi-continuous type.

2.2.2.3.1. By way of derogation from the requirement of point 2.2.2.3., an inertia braking system may be fitted to vehicles of category R3a and S2a with a maximum mass not exceeding 8000 kg under the following conditions:

2.2.2.3.1.1. design speed not exceeding 30 km/h when the brakes act not on all wheels;

2.2.2.3.1.2. design speed not exceeding 40 km/h when the brakes act on all wheels;

2.2.2.3.1.3. a durable plate (150mm in diameter) shall be fitted to the rear of trailers in category R3a, fitted with inertia brakes, indicating the maximum design speed. This shall read 30 or 40 km/h as applicable; or 20 or 25 mph in Member States where imperial units are still in use.

2.2.2.4. The service braking system:

2.2.2.4.1. shall act at least on two wheels of each axle in the case of towed vehicle of categories Rb and Sb;

2.2.2.4.2. shall distribute its action appropriately among the axles;

2.2.2.4.3. shall contain in at least one of the air reservoirs, if fitted, a device for draining and exhausting in an adequate and easily accessible position.

2.2.2.5. The action of every braking system shall be distributed between the wheels of each axle symmetrically in relation to the longitudinal median plane of the towed vehicle.

2.2.2.5.1. However, in the case of vehicle with significantly different wheel loads on the left and right vehicle side, the action of the braking system may deviate from the symmetrical brake force distribution accordingly.

2.2.2.6. Malfunctions of the electric control transmission shall not apply the brakes contrary to the driver's intentions.

2.2.2.7. The braking surfaces required to attain the prescribed degree of effectiveness shall be in constant contact with the wheels, either rigidly or through components not liable to failure.

2.2.2.8. Wear of the brakes shall be capable of being easily taken up by means of a system of manual or automatic adjustment. In addition, the control device and the components of the transmission and of the brakes shall possess a reserve of travel and, if necessary, suitable means of compensation such that, when the brakes become heated, or the brake linings have reached a certain degree of wear, effective braking is ensured without immediate adjustment being necessary.

2.2.2.8.1. Wear adjustment shall be automatic for the service brakes. However, the fitting of automatic adjustment devices is optional for vehicles of categories R1, R2, R3a, S1 and S2a. Brakes equipped with automatic brake adjustment devices shall, after heating followed by cooling, be capable of free running as specified in point 2.5.6. of Annex II following the type-I or type-III test also defined in that Annex as appropriate.

2.2.2.8.1.1. In the case of towed vehicles of categories:

- R3a, R4a, S2a, and

- R3b, R4b, S2b where the sum of the technically permissible masses per axle does not exceed 10,000 kg,

the performance requirements of point 2.2.2.8.1. shall be deemed to be satisfied by fulfilling the requirements of point 2.5.6. of Annex II. Until uniform technical provisions have been agreed that correctly assess the function of the automatic brake adjustment device, the free running requirement shall be deemed to be fulfilled when free running is observed during all brake tests prescribed for the relevant trailer.

2.2.2.8.1.2. In the case of towed vehicles of categories R3b, R4b, S2b where the sum of the technically permissible masses per axle exceeds 10,000 kg, the performance requirements of point 2.2.2.8.1. shall be deemed to be satisfied by fulfilling the requirements of point 2.5.6. of Annex II.

2.2.2.9. The braking system shall be such that the towed vehicle is stopped automatically if the coupling separates while the towed vehicle is in motion.

2.2.2.9.1. Vehicles of categories R1 and S1, without a braking system, shall be equipped, in addition to the main coupling device, with a secondary coupling (chain, cable etc.) capable, in the event of separation of the main coupling, of preventing the drawbar from touching the ground and providing some residual steering action on the towed vehicle.

2.2.2.9.2. Vehicles of categories R1, R2, R3a, S1 and S2a where an inertia braking system is fitted shall be equipped with a device (chain, cable etc.) capable, in the event of separation of the coupling, of applying the towed vehicle brakes.

2.2.2.9.3. On towed vehicles with a hydraulic braking system the connecting lines, as specified in points 2.1.5.1.1. and 2.1.5.1.2. shall disconnect on the tractor or on the towed vehicle with an insignificant leakage during the separation of the coupling. The force to disconnect a single connection line shall not exceed the values specified in ISO 5675:2008. Deviating from the values prescribed in paragraph 4.2.4. of this standard, the disconnecting force for both lines shall not exceed 2,500 N.

2.2.2.10. On every towed vehicle which is required to be fitted with a service braking system, parking braking shall be ensured even when the towed vehicle is separated from the tractor. It shall be possible for a person standing on the ground to actuate the parking braking system.

2.2.2.11. If the towed vehicle is fitted with a device enabling actuation of the braking system to be cut out, other than the parking braking system, the device shall be so designed and constructed that it is positively restored to the 'at rest' position not later than on the resumption of the supply of compressed air or hydraulic oil or electrical supply to the towed vehicle.

2.2.2.12. On every towed vehicle which is fitted with a hydraulic service braking system the braking system shall be so designed such that when the supplementary line is disconnected the parking or service braking system shall be automatically applied.

2.2.2.13. Vehicles of categories R3, R4 and S2 shall satisfy the conditions specified in point 2.2.1.17.2.2. for compressed-air braking systems or in point 2.2.2.15.3. for hydraulic braking systems respectively.

2.2.2.14. Where the auxiliary equipment is supplied with energy from the service braking system, the service braking system shall be protected to ensure that the pressure in the service brake storage device(s) is maintained at a pressure of at least 80 % of the control line demand pressure or equivalent digital demand as specified respectively in points 2.2.3.2. and 2.2.3.3. of Annex II.

2.2.2.15. In addition to the above, towed vehicles with hydraulic braking systems shall comply with the following:

2.2.2.15.1. In the case that a towed vehicle only complies with the requirements of the service braking system and/or parking braking system and/or automatic braking with the assistance of energy stored in a hydraulic energy storage device, the towed vehicle shall automatically apply the brakes or remain braked when it is not electrically connected (ignition of tractor is switched on) with the energy supply available from the ISO 7638:2003 connector (see also point 2.2.1.18.9.). The ISO 7638:2003 connector may be used for 5 pin or 7 pin applications, as appropriate.

2.2.2.15.1.1. When the pressure in the hydraulic energy storage devices falls below a pressure declared by the vehicle manufacturer in the type-approval certificate where the prescribed braking performance(s) is (are) not ensured this low pressure shall be indicated to the driver by the separate warning signal specified in point 2.2.1.29.2.2. via pin 5 of the electrical connector conforming to ISO 7638:2003.

This pressure shall not exceed 11,500 kPa

2.2.2.15.2. When the supplementary line has fallen to a pressure of 1,200 kPa the automatic braking of the towed vehicle shall start (see also point 2.2.1.18.6.).

2.2.2.15.3. A device may be installed on the towed vehicle to temporary release the brakes in the case that no suitable tractor is available. The supplementary line shall be connected to this device for this temporary purpose. When the supplementary line is disconnected from this device the brakes shall return automatically to the applied condition again.

2.2.2.16. Towed vehicles with a maximum design speed exceeding 60 km/h of categories R3b, R4b and S2b shall be equipped with an anti-lock braking system in accordance with Annex XI. Additionally, if the maximum permissible mass of the towed vehicles exceeds 10 t only an anti-lock braking system of category A is permitted.

2.2.2.17. If towed vehicles not mentioned in point 2.2.2.16. are fitted with anti-lock braking systems, they shall comply with the requirements of Annex XI.

2.2.2.18. Towed vehicles equipped with an electric control line and R3b or R4b category towed vehicles equipped with an anti-lock braking system, shall be fitted with a special electrical connector for the braking system and anti-lock braking system or only for one of those two systems, conforming to ISO 7638:2003 . The conductor cross sections specified in ISO 7638:2003 for the trailer may be reduced if the trailer is installed with its own independent fuse. The rating of the fuse shall be such that the current rating of the conductors is not exceeded. This derogation shall not apply to trailers equipped to tow another trailer. Failure warning signals required from the towed vehicle by this Regulation shall be activated via the above connector. The requirement to be applied to towed vehicles with respect to the transmission of failure warning signals shall be those, as appropriate, which are prescribed for tractors in points 2.2.1.29.3., 2.2.1.29.4., 2.2.1.29.5. and 2.2.1.29.6.

Those vehicles shall be marked in indelible form, in accordance with the requirements laid down on the basis of Article 17 (2) (k) and (5) of Regulation (EU) No 167/2013, to indicate the functionality of the braking system when the ISO 7638:2003 connector is connected and disconnected. The marking is to be positioned so that it is visible when connecting the pneumatic and electrical interface connections.

2.2.2.18.1. It is permitted to connect the braking system to a power supply in addition to that available from the ISO 7638:2003 connector above. However, when an additional power supply is available the following provisions shall apply:

2.2.2.18.1.1. in all cases the ISO 7638:2003 power supply is the primary power source for the braking system, irrespective of any additional power supply that is connected. The additional supply is intended to provide a backup should a failure of the ISO 7638:2003 power supply occur;

2.2.2.18.1.2. it shall not have an adverse effect on the operation of the braking system under normal and failed modes;

2.2.2.18.1.3. in the event of a failure of the ISO 7638:2003 power supply the energy consumed by the braking system shall not result in the maximum available power from the additional supply being exceeded;

2.2.2.18.1.4. the towed vehicle shall not have any marking or label to indicate that the towed vehicle is equipped with an additional power supply;

2.2.2.18.1.5. a failure warning device is not permitted on the towed vehicle for the purposes of providing a warning in the event of a failure within the towed vehicle braking system when the braking system is powered from the additional supply;

2.2.2.18.1.6. when an additional power supply is available it shall be possible to verify the operation of the braking system from this power source;

2.2.2.18.1.7. should a failure exist within the electrical supply of energy from the ISO 7638:2003 connector the requirements of points 4.2.3. of Annex XII and 4.1 of Annex XI with respect to failure warning shall apply irrespective of the operation of the braking system from the additional power supply.

2.2.2.19. In addition to the requirements of points 2.2.1.17.2.2. and 2.2.1.19. , the brakes of the towed vehicle may also be applied automatically when this is initiated by the towed vehicle braking system itself following the evaluation of on-board generated information.

3. Tests

Braking tests which the vehicles submitted for approval are required to undergo, and the braking performance required, are described in Annex II.

ANNEX II

Requirements applying to testing and performance of braking systems and trailer braking couplings and of vehicles fitted with them

1. Definitions

For the purposes of this Annex:

1.1. ‘axle group’ means multiple axles where the axle spread between one axle and its adjacent axle is equal to or less than 2.0 m. Where the axle spread between one axle and its adjacent axle is greater than 2.0 m, each individual axle shall be considered as an independent axle group.

1.2. ‘adhesion utilization curves’ of a vehicle means curves showing, for specified load conditions, the adhesion utilized by each axle i plotted against the braking rate of the vehicle.

2. Braking tests

2.1. General

The maximum design speed is considered, throughout this Annex, to be in the forward direction of the vehicle travel, unless otherwise explicitly mentioned.

2.1.1. The performance prescribed for braking systems shall be based on the stopping distance and the mean fully developed deceleration or only on one of those two quantities. The performance of a braking system shall be determined by measuring the stopping distance in relation to the initial speed of the vehicle and by measuring the mean fully developed deceleration during the test or only on one of those two quantities. Both stopping distance and mean fully developed deceleration or only one of them shall be prescribed and measured, following to the test to be performed.

2.1.2. The stopping distance shall be the distance covered by the vehicle from the moment when the driver begins to actuate the control device of the braking system until the moment when the vehicle stops; the initial vehicle speed (v1) shall be the speed at the moment when the driver begins to actuate the control device of the braking system; the initial speed shall not be less than 98 % of the prescribed speed for the test in question. The mean fully developed deceleration d_m shall be calculated as the deceleration averaged with respect to distance over the interval v_b to v_e according to the following formula:

$$d_m = \frac{v_b^2 - v_e^2}{25{,}92(s_e - s_b)} m/s^2$$

Where:

v_1	=	initial vehicle speed calculated as described in the first subparagraph
v_b	=	vehicle speed at 0.8 v_1 in km/h

v_e = vehicle speed at 0.1 v_1 in km/h

s_b = distance travelled between v_1 and v_b in metres

s_e = distance travelled between v_1 and v_e in metres

The speed and distance shall be determined using instrumentation having an accuracy of ± 1 % at the prescribed speed for the test. The d_m may be determined by other methods than the measurement of speed and distance; in this case, the accuracy of the d_m shall be within ± 3 %.

2.1.3. For the type-approval of any vehicle, the braking performance shall be measured during road tests conducted in the following conditions:

2.1.3.1. The vehicle's condition as regards mass shall be as prescribed for each type of test and be specified in the test report.

2.1.3.2. The test shall be carried out at the speeds prescribed for each type of test; if the maximum design speed of a vehicle is lower than the speed prescribed for a test, the test shall be performed at the vehicle's maximum design speed.

2.1.3.3. During the tests, the force applied to the control device of the braking system in order to obtain the prescribed performance shall not exceed 600 N on the foot or 400 N on the hand operated control devices.

2.1.3.4. The road shall have a surface affording good adhesion, unless specified otherwise.

2.1.3.5. The tests shall be performed when there is no wind liable to affect the results.

2.1.3.6. At the start of the tests the tyres shall be cold and at the pressure prescribed for the load actually borne by the wheels when the vehicle is stationary.

2.1.3.7. The prescribed performance shall be obtained without deviation of the vehicle from its course, without abnormal vibrations and without wheel-locking. Wheel-locking is permitted where specifically mentioned.

2.1.4. Behaviour of the vehicle during braking

2.1.4.1. In braking tests, and in particular in those at high speed, the general behaviour of the vehicle during braking shall be checked.

2.1.4.2. Behaviour of the vehicle during braking on a road on which adhesion is reduced.

The behaviour of vehicles of categories Tb, R2b, R3b, R4b and S2b on a road on which adhesion is reduced, shall meet the relevant requirements of Appendix 1 and, if the vehicle is equipped with ABS, of Annex XI too.

2.2. Type-0 braking test (ordinary performance test with brakes cold)

2.2.1. General

2.2.1.1. The brake shall be cold. A brake is deemed to be cold when one of the following conditions is met:

2.2.1.1.1. The temperature measured on the disc or on the outside of the drum is below 100 °C.

2.2.1.1.2. In the case of totally enclosed brakes, including oil immersed brakes, the temperature measured on the outside of the housing is below 50 °C.

2.2.1.1.3. The brakes have not been used for one hour before the test.

2.2.1.2. During the braking test, an axle without a brake, when this axle is capable of being declutched, shall not be connected with a braked axle. However, in case of tractors with one braked axle and an automatic engagement of the drive to all other axles during braking, all wheels are deemed to be braked.

2.2.1.3. The test shall be conducted under the following conditions:

2.2.1.3.1. The vehicle shall be laden to its maximum permissible mass specified by the manufacturer and with an unbraked axle loaded to its maximum permissible mass. The braked axle wheels shall be fitted with the largest diameter tyres intended by the manufacturer for that vehicle type when carrying the maximum permissible mass. For vehicles braking on all wheels, the front axle shall be laden to its maximum permissible mass.

2.2.1.3.2. The test shall be repeated on an unladen vehicle; in case of tractors, carrying only the driver and if necessary a person responsible for monitoring the results of the test.

2.2.1.3.3. The limits prescribed for minimum performance, both for tests with the vehicle unladen and for tests with the vehicle laden, are those laid down hereunder for each category of vehicle, the vehicle shall satisfy both the prescribed stopping distance and the prescribed mean fully developed deceleration for the relevant vehicle category, but it may not be necessary to actually measure both parameters.

2.2.1.3.4. The road shall be level.

2.2.2. Type-0 test for categories T and C vehicles

2.2.2.1. The test shall be carried out at the maximum design speed of the vehicle, with the engine disconnected. This speed may be subject to a certain margin of tolerance. However, in any case the minimum prescribed performance shall be attained. The prescribed maximum stopping distance (by the stopping distance formula) shall be calculated with the actual test speed.

2.2.2.2. To check compliance with the requirements of point 2.2.1.2.4. of Annex I, a type-0 test shall be carried out with the engine disconnected at the initial speed of not less than 98 % of the maximum design speed of the vehicle. The mean fully developed deceleration on application of the control device of the parking braking system or on application of an auxiliary control device, which permits at least partial actuation of the service braking system and the deceleration immediately before the vehicle stops shall not be less than 1.5 m/s^2 up to 30 km/h and 2.2 m/s^2 above 30 km/h. The test

shall be carried out with the laden vehicle. The force exerted on the braking control device shall not exceed the specified values.

2.2.2.3. In the case of vehicles equipped with handlebar and straddle seat or equipped with steering wheel and bench seat or bucket seats in one or more rows, that are also equipped with non-disengageable transmission, as this can be proved by the manufacturer at the braking testing, the vehicle shall complete the Type-0 test with the engine connected.

2.2.3. Type-0 test for categories R and S vehicles:

2.2.3.1. The braking performance of the towed vehicle can be calculated either from the braking rate of the tractor plus the towed vehicle and the measured thrust on the coupling or, in certain cases, from the braking rate of the tractor plus the towed vehicle with only the towed vehicle being braked. The engine of the tractor shall be disconnected during the braking test.

2.2.3.2. If the towed vehicle is fitted with a compressed-air braking system, the pressure in the supply line shall not exceed 700 kPa during the brake test and the signal value in the control line shall not exceed the following values, depending on the installation:

2.2.3.2.1. 650 kPa in the pneumatic control line;

2.2.3.2.2. A digital demand value corresponding to 650 kPa (as defined in ISO 11992:2003 including ISO 11992-2:2003 and its Amd.1:2007 in the electric control line.

2.2.3.3. If the towed vehicle is fitted with a hydraulic braking system:

2.2.3.3.1. The prescribed minimum braking performance shall be achieved with a pressure at the coupling head of the control line not exceeding 11,500 kPa

2.2.3.3.2. The maximum pressure delivered at the coupling head of the control line shall not exceed 15,000 kPa .

2.2.3.4. With the exception of cases according to points 2.2.3.5. and 2.2.3.6. , it is necessary for the determination of the braking rate of the towed vehicle to measure the braking rate of the tractor plus the towed vehicle and the thrust on the coupling. The tractor shall meet the requirements laid down in Appendix 1 with regard to the relation between the ratio T_M/F_M and the pressure p_m,

where:

T_M	=	sum of braking forces at the periphery of all wheels of tractors
F_M	=	total normal static reaction of road surface on wheels of tractors
p_m	=	pressure at coupling head of control line

The braking rate of the towed vehicle shall be calculated according to the following formula:

$z_R = z_R + M + D / F_R$

Where:

z_R	=	braking rate of the towed vehicle
z_{R+M}	=	braking rate of the tractor plus the towed vehicle
D	=	thrust on the coupling (tractive force D > 0; compressive force D < 0)
F_R	=	total normal static reaction of road surface on all wheels of towed vehicle

2.2.3.5. If a towed vehicle has a continuous or semi-continuous braking system where the pressure in the brake actuators does not change during braking despite the dynamic axle load shifting, the towed vehicle alone may be braked. The braking rate z_R of the towed vehicle shall be calculated according to the following formula:

Where:

$$z_R = (z_{R+M} - R) \cdot \frac{F_M + F_R}{F_R} + R$$

R = rolling resistance value:

- 0.02 in the case of vehicles with a maximum design speed not exceeding 40 km/h
- 0.01 in the case of vehicles with a maximum design speed exceeding 40 km/h

F_M = total normal static reaction of road surface on wheels of tractors

F_R = total normal static reaction of road surface on all wheels of towed vehicle

2.2.3.6. Alternatively, the evaluation of the braking rate of the towed vehicle may be done by braking the towed vehicle alone. In this case the pressure used shall be the same as that measured in the brake actuators during the braking of the combination.

2.3. Type-I test (fade test)

This test type shall be performed according to the requirements of points 2.3.1. or 2.3.2., as applicable.

2.3.1. With repeated braking

Tractors of categories T and C shall undergo the Type-I test with repeated braking.

2.3.1.1. The service braking system of tractors covered by this Regulation shall be tested by successively applying and releasing the brakes a number of times. The vehicle shall be fully laden and tested in accordance with the conditions shown in the following table:

Vehicle category	Conditions			
	v_1 [km/h]	v_2 [km/h]	Δt [sec]	n
T, C	80 % v_{max}	½ v_1	60	20

Where

v_1 = speed at start of braking

v_2 = speed at end of braking

v_{max} = maximum design speed of vehicle

n = number of brake applications

Δt = duration of the braking cycle (time elapsing between the initiation of one brake application and the initiation of the next).

2.3.1.1.1. In the case of tractors with a maximum design speed not exceeding 40 km/h, as an alternative to the test conditions as shown in the table of point 2.3.1.1. the conditions shown in the following table may be applied:

Vehicle category	Conditions			
	v_1 [km/h]	v_2 [km/h]	Δt [sec]	n
T, C	80 % v_{max}	0.05 v_1	60	18

2.3.1.2. If the characteristics of the vehicle do not allow for the period of time prescribed for Δt, the duration may be increased; in any event, in addition to the time necessary for braking and accelerating the vehicle, a period of 10 seconds shall be allowed in each cycle for stabilising the speed v_1.

2.3.1.3. In these tests, the force applied to the control device shall be so adjusted as to attain a mean fully developed deceleration of 3 m/s² at the first application of the brakes. This force shall remain constant throughout the succeeding brake applications.

2.3.1.4. During brake applications the highest gear ratio (excluding overdrive, etc.) shall be continuously engaged.

2.3.1.5. For regaining speed after braking, the gearbox shall be used in such a way as to attain the speed v_1 in the shortest possible time (maximum acceleration allowed by the engine and gearbox).

2.3.1.6. In the case of vehicles equipped with automatic brake adjustment devices the adjustment of the brakes shall, prior to the type-I test above, be set according to the following procedures as appropriate:

2.3.1.6.1. In the case of vehicles equipped with air operated brakes the adjustment of the brakes shall be such as to enable the automatic brake adjustment device to function. For this purpose the actuator stroke shall be adjusted to:

$$s_o \geq 1.1 \times s_{re\text{-}adjust}$$

(the upper limit shall not exceed a value recommended by the manufacturer)

Where:

$S_{re\text{-}adjust}$ is the re-adjustment stroke according to the specification of the manufacturer of the automatic brake adjustment device, i.e. the stroke, where it starts to readjust the running clearance of the brake with an actuator pressure of 15 per cent of the brake system operating pressure but not less than 100 kPa.

Where, by agreement with the technical service, it is impractical to measure the actuator stroke, the initial setting shall be agreed with the technical service.

From the above condition the brake shall be operated with an actuator pressure of 30 % of the brake system operating pressure but not less than 200 kPa 50 times in succession. This shall be followed by a single brake application with an actuator pressure of > 650 kPa.

2.3.1.6.2. In the case of vehicles equipped with hydraulically operated disc brakes no setting requirements are deemed necessary.

2.3.1.6.3. In the case of vehicles equipped with hydraulically operated drum brakes the adjustment of the brakes shall be as specified by the manufacturer.

2.3.2. With continuous braking

2.3.2.1. The service braking system of vehicles of categories R1, R2, S1, R3a, R4a, S2a and R3b, R4b, S2b, where the sum of the technically permissible masses per axle does not exceed 10,000 kg for the three last vehicles' categories

When the above mentioned vehicles R3a, R4a, S2a and R3b, R4b, S2, where the sum of the technically permissible masses per axle does not exceed 10,000 kg for the three last vehicles' categories, have not passed alternatively the Type-III test according to point 2.5 shall be tested in such a manner that, the vehicle being laden, the energy input to the brakes is equivalent to that recorded in the same period of time with a laden vehicle driven at a steady speed of 40 km/h on a 7% down-gradient for a distance of 1.7 km.

2.3.2.2. The test may be carried out on a level road, the trailed vehicle being towed by a agricultural vehicle; during the test, the force applied to the control device shall be adjusted so as to keep the resistance of the towed vehicle constant (7 % of the maximum stationary axle load of the towed vehicle). If the power available for hauling is insufficient, the test can be conducted at a lower speed but over a greater distance; as shown in the following table:

Speed (km/h)	distance (in m)
40	1,700
30	1,950
20	2,500
15	3,100

2.3.2.3. In the case of towed vehicles equipped with automatic brake adjustment devices the adjustment of the brakes shall, prior to the Type-I test prescribed above, be set according to the procedure as laid down in point 2.5.4.

2.3.3. Hot performance

2.3.3.1. At the end of the type-I test (test described in point 2.3.1. or test described in point 2.3.2.) the hot performance of the service braking system shall be measured in the same conditions (and in particular at a constant control force no greater than the mean force actually used) as for the type-0 test with the engine disconnected (the temperature conditions may be different).

2.3.3.2. For tractors this hot performance shall not be less than 80% of that prescribed for the category in question, nor less than 60% of the figure recorded in the type-0 test with the engine disconnected.

2.3.3.3. In the case of towed vehicles, the hot brake force at the periphery of the wheels when tested at 40 km/h shall not be less than 36% of towed vehicles with v_{max} > 30 km/h or 26% of towed vehicles with $v_{max} \leq 30$ km/h of the maximum stationary wheel load, nor less than 60% of the figure recorded in the type 0 test at the same speed.

2.3.4. Free running test

In the case of tractors equipped with automatic brake adjustment devices, the brakes after completing the tests described in point 2.3.3. shall be allowed to cool to a temperature representative of a cold brake (i.e. ≤ 100 °C) and it shall be verified that the vehicle is capable of free running by fulfilling one of the following conditions:

2.3.4.1. Wheels are running freely (i.e. may be rotated by hand);

2.3.4.2. It is ascertained that when the vehicle is driven at a constant speed of v = 60 km/h with the brakes released the asymptotic temperatures shall not exceed a drum/disc temperature increase of 80°C, then the residual brake moments are regarded as acceptable.

2.4. Type-II test (downhill behaviour test)

In addition to the type-I test, tractors of categories Tb and Cb having a maximum permissible mass exceeding 12 t, shall also undergo the type-II test.

2.4.1. Laden tractor shall be tested in such a manner that the energy input is equivalent to that recorded in the same period of time with a laden tractor driven at an average speed of 30 km/h on a 6% down-gradient for a distance of 6 km, with the appropriate gear engaged and the endurance braking system, if the vehicle is equipped with one, being used. The gear engaged shall be such that the speed of the engine (min^{-1}) does not exceed the maximum value prescribed by the manufacturer.

2.4.2. For vehicles in which the energy is absorbed by the braking action of the engine alone, a tolerance of ±5 km/h on the average speed shall be permitted, and the gear enabling the speed to be stabilized at the value closest to 30 km/h on the 6% down-gradient shall be engaged. If the performance of the braking action of the engine alone is determined by a measurement of deceleration, it shall be sufficient if the mean deceleration measured is at least 0.5 m/s^2.

2.4.3. At the end of the test, the hot performance of the service braking system shall be measured in the same conditions as for the type-0 test with the engine disconnected (the temperature conditions may be different). This hot performance shall give a stopping distance not exceeding the following values and a mean fully developed deceleration not less than the following values, using a control force not exceeding 60 daN:

$0.15\ v + (1.33\ v^2/115)$ (the second term corresponds to a mean fully developed deceleration $d_m = 3.3\ m/s^2$).

2.5. Type-III test (fade test) for laden vehicles of categories:

2.5.1. R3b, R4b, S2b where the sum of the technically permissible masses per axle exceeds 10,000 kg

or alternatively of categories

2.5.2. R3a, R4a, S2a, when these vehicles have not been tested according to point 2.3.2.

2.5.3. R3b, R4b, S2b where the sum of the technically permissible masses per axle does not exceed 10,000 kg.

2.5.4. Track test

2.5.4.1. The adjustment of the brakes shall, prior to the type-III test below, be set according to the following procedures as appropriate:

2.5.4.1.1. In the case of towed vehicles equipped with air operated brakes the adjustment of the brakes shall be such as to enable the automatic brake adjustment device to function. For this purpose the actuator stroke shall be adjusted to:

$$s_o \geq 1.1 \times s_{re\text{-}adjust}$$

(the upper limit shall not exceed a value recommended by the manufacturer)

Where:

$s_{re\text{-}adjust}$ is the re-adjustment stroke according to the specification of the manufacturer of the automatic brake adjustment device, i.e. the stroke, where it starts to readjust the running clearance of the brake with an actuator pressure of 100 kPa.

Where, by agreement with the technical service, it is impractical to measure the actuator stroke, the initial setting shall be agreed with the technical service.

From the above condition the brake shall be operated with an actuator pressure of 200 kPa, 50 times in succession. This shall be followed by a single brake application with an actuator pressure of ≥ 650 kPa.

2.5.4.1.2. In the case of towed vehicles equipped with hydraulically operated disc brakes no setting requirements are deemed necessary.

2.5.4.1.3. In the case of towed vehicles equipped with hydraulically operated drum brakes the adjustment of the brakes shall be as specified by the manufacturer.

2.5.4.2. For the road test the conditions shall be as follows:

Number of brake applications	20
Duration of a braking cycle	60 s
Initial speed at the beginning of braking	60 km/h
Braking applications	In these tests, the force applied to the control device shall be so adjusted as to attain the mean fully developed deceleration of 3 m/s^2 in respect to the towed vehicle mass P_R at the first brake application; this force shall remain constant throughout the succeeding brake applications.

The braking rate of a towed vehicle is calculated according to the formula given in point 2.2.3.5:

$$z_R = (z_{R+M} - R) . \frac{(F_M + F_R)}{F_R} + R$$

$$v_2 = v_1 \cdot \sqrt{\frac{F_M + F_1 + F_2/4}{F_M + F_1 + F_2}}$$

The speed at the end of braking:

Where:

z_R = braking rate of the towed vehicle,

z_{R+M} = braking rate of the vehicle combination (tractor and towed vehicle),

R = rolling resistance value = 0.01

F_M = total normal static reaction between the road surface and the wheels of tractor (N),

F_R = total normal static reaction between the road surface and the wheels of towed vehicle (N),

F_1 = normal static reaction of the part of the mass of the towed vehicle borne by the unbraked axle(s) (N),

F_2 = normal static reaction of the part of the mass of the towed vehicle borne by the braked axle(s) (N),

P_R = $P_R = F_R / g$

v_1 = initial speed (km/h),

v_2 = final speed (km/h).

2.5.5. Hot performance

At the end of the test according to point 2.5.4., the hot performance of the service braking system shall be measured under the same conditions as for the Type-0 test with, however, different temperature conditions and starting from an initial speed of 60 km/h. The hot brake-force at the periphery of the wheels shall then not be less than 40% of the maximum stationary wheel load, and not less than 60 per cent of the figure recorded in the Type-0 test at the same speed.

2.5.6. Free running test

After completing the tests described in point 2.5.5., the brakes shall be allowed to cool to a temperature representative of a cold brake (i.e. < 100°C) and it shall be verified that the towed vehicle is capable of free running by fulfilling one of the following conditions:

2.5.6.1. Wheels are running freely (i.e. may be rotated by hand);

2.5.6.2. It is ascertained that when the towed vehicle is driven at a constant speed of v = 60 km/h with the brakes released the asymptotic temperatures shall not exceed a drum/disc temperature increase of 80°C, then the residual brake moments are regarded as acceptable.

3. Performances of the braking systems

3.1. Vehicles of category T and C

3.1.1. Service braking systems

3.1.1.1. Under Type-0 conditions, the service braking system shall be tested under the conditions shown in the following table

	$v_{max} \leq 30$ km/h	$v_{max} > 30$ km/h
v	$= v_{max}$	$= v_{max}$
s (metres)	$\leq 0.15\ v + v^2/92$	$\leq 0.15\ v + v^2/130$
d_m	≥ 3.55 m/s²	≥ 5 m/s²
F (foot operated control)	≤ 600 N	≤ 600 N
F (hand operated control)	≤ 400 N	≤ 400 N

where:

v_{max}	=	maximum design speed of the vehicle
v	=	prescribed test speed
s	=	Stopping distance
d_m	=	mean fully developed deceleration
F	=	force applied to the control device

3.1.1.2. In the case of a tractor authorized to tow an unbraked vehicle of categories R or S, the minimum performance prescribed for the corresponding tractor (for the type-0 test with engine disconnected) shall be attained with the unbraked towed vehicle coupled to the tractor and with the unbraked towed vehicle laden to the maximum mass declared by the tractor manufacturer.

The combination performance shall be verified by calculations referring to the maximum braking performance actually achieved by the tractor alone during the Type-0 test with the engine disconnected for the laden and unladen tractor (optionally also for a partially laden condition defined by the tractor manufacturer), using the following formula (no practical tests with a coupled unbraked towed vehicle are required):

$$d_{M+R} = d_M \cdot \frac{P_M}{P_M + P_R}$$

Where:

d_{M+R}	=	calculated mean fully developed deceleration of the tractor when coupled to an unbraked towed vehicle, in m/s^2,
d_M	=	maximum mean fully developed deceleration of the tractor alone achieved during the Type-0 test with engine disconnected, in m/s^2,
P_M	=	mass of the tractor (if applicable, including any ballast and/or supporting load)
P_{M_laden}	=	mass of the tractor, laden
$P_{M\_par\_laden}$	=	mass of the tractor, partial laden
$P_{M\_unladen}$	=	mass of the tractor, unladen
P_R	=	part of the maximum mass borne by the axle(s) of a towed vehicle without a service brake which may be coupled (as declared by the tractor manufacturer)
P_{M+R}'	=	combination mass (mass 'PM' + declared unbraked towed vehicle mass P_R)

3.1.1.2.1. Required minimum combination performance

The minimum combination performance shall be not less than 4.5 m/s² in the case of tractors with $v_{max} > 30$ km/h and not less than 3.2 m/s² in the case of tractors with $v_{max} \leq 30$ km/h for the laden und unladen conditions. At the discretion of the tractor manufacturer, an additional type-0 test may be carried out by the technical service for a partial laden tractor mass declared by the manufacturer in order to define the maximum permitted unbraked towed vehicle mass fulfilling the required minimum combination performance for such 'combination mass'.

The measured figures 'd_m' for the above mentioned load conditions and the corresponding calculated figures 'd_{M+R}' shall be recorded in the test report.

The maximum declared figure for the unbraked towed vehicle mass shall not exceed 3,500 kg.

3.1.2. Secondary braking system

The secondary braking system, even if the control device which actuates it is also used for other braking functions, shall give a stopping distance not exceeding the following values and a mean fully developed deceleration not less than the following values:

Tractors with $v_{max} \leq 30$ km/h: $0.15\ v + (v^2/39)$

(the second term corresponds to a mean fully developed deceleration $d_m = 1{,}5\ m/s^2$)

Tractors with $v_{max} > 30$ km/h: $0.15\ v + (v^2/57)$

(the second term corresponds to a mean fully developed deceleration $d_m = 2.2\ m/s^2$)

The prescribed performance shall be obtained by applying to the control device a force not exceeding 600 N on a foot or 400 N on a hand operated control device. The control device shall be so placed that it can be easily and quickly applied by the driver.

3.1.3. Parking braking system

3.1.3.1. The parking braking system shall, even if it is combined with one of the other braking devices, be capable of holding a laden tractor on an 18 % up and down gradient. This requirement shall be fulfilled even during the cooling period. The cooling period is deemed to terminate when the brakes have reached a temperature of 10 °C above ambient.

3.1.3.2. For vehicles of category T4.3, the parking braking system shall, even if it is combined with one of the other braking devices, be capable of holding a laden tractor on a 40 % up and down gradient. This requirement shall be fulfilled even during the cooling period. The cooling period is deemed to terminate when the brakes have reached a temperature of 10 °C above ambient.

3.1.3.3. Hot and cold parking braking performance test

In order to verify that the parking brake is capable of holding a laden tractor on an up and down gradient as required by points 3.1.3.1. and 3.1.3.2. , the measurements shall be done under the following conditions:

- Heating up the brakes on a temperature ≥ 100 °C (measured at the rubbing surface of the disc or at the outside of the drum);
- Hot static parking braking system test at a temperature ≥ 100 °C;
- Cold static parking braking system test at a temperature ≤ ambient temperature + 10 °C.

In the case of oil immersed brakes, the method by which this check is carried out shall be agreed between the vehicle manufacturer and the technical service. The method of assessment and results shall be appended to the type approval report.

3.1.3.4. On tractors to which the coupling of towed vehicles is authorised, the parking braking system of the tractor shall be capable of holding the vehicle combination, at the maximum permissible mass as specified by the tractor manufacturer, stationary on a 12 % up or down gradient.

In the case that this requirement cannot be met due to physical limitations (e.g. limited available tyre/road adhesion for the tractor to generate sufficient braking forces) this requirement is deemed to be fulfilled when the alternative requirement of point 3.1.3.4. in connection with point 2.2.1.20. of Annex I is complied with.

3.1.3.4.1. The requirement of point 3.1.3.4. is considered to be fulfilled when conditions 3.1.3.4.1.1. or 3.1.3.4.1.2. below are met:

3.1.3.4.1.1. Even with the tractor engine not rotating, the combination at the maximum permissible mass remains stationary on the prescribed gradient when the activation of a single control device by the driver, from his driving seat, has applied the tractor

parking braking system and the towed vehicle service braking system or only one of those two braking systems.

3.1.3.4.1.2. The tractor parking braking system can hold stationary the tractor connected to an unbraked towed vehicle having a mass equal to the highest 'combination mass P_{M+R}' mentioned in the test report.

'P_{M+R}' = combination mass (mass 'PM' + declared unbraked towed vehicle mass P_R) according to point 3.1.1.2. and of the test report.

'PM' = mass of the tractor (if applicable, including any ballast or supporting load or both of them).

3.1.3.5. A parking braking system which has to be actuated several times before attaining the prescribed performance is permissible.

3.1.4. Residual braking after transmission failure

3.1.4.1. In the case of category Tb tractors with a maximum design speed exceeding 60 km/h, the residual performance of the service braking system, in the event of failure in a part of its transmission, shall give a stopping distance not exceeding the following values and a mean fully developed deceleration not less than the following values, using a control force not exceeding 70 daN, when checked by the type-0 test with the engine disconnected from the following initial speeds for the relevant vehicle category:

v [km/h]	*Stopping distance LADEN - [m]*	*d_m [m/s^2]*	*Stopping distance UNLADEN - [m]*	*d_m [m/s^2]*
40	0.15v +(100/30) · (v^2/115)	1.3	0.15v +(100/30) · (v^2/115)	1.3

That requirement shall not be construed as a departure from the requirements concerning secondary braking.

3.1.4.2. The residual braking effectiveness test shall be conducted by simulating the actual failure conditions in the service braking system.

3.2. Vehicles of the categories R and S

3.2.1. Service braking system

3.2.1.1. Requirement relating to tests of category R1 or S1 vehicles

If towed vehicles of category R1 or S1 are fitted with a service braking system, the performance of the system shall meet the requirements laid down for category R2 or S2 vehicles.

3.2.1.2. Requirement relating to tests of category R2 vehicles

If the service braking system is of the continuous or semi-continuous type, the sum of the forces exerted at the periphery of the braked wheels shall be at least X % of the maximum stationary wheel load.

X = 50 for towed vehicle with a maximum design speed exceeding 30 km/h

X = 35 for towed vehicle with a maximum design speed not exceeding 30 km/h

Where the towed vehicle is fitted with a compressed-air braking system, the pressure in the control line shall not exceed 650 kPa (and/or a corresponding digital demand value as defined in ISO 11992:2003 including ISO 11992-2:2003 and its Amd.1:2007 in the electric control line) and the pressure in the supply line shall not exceed 700 kPa during the brake test.

Where the towed vehicle is fitted with a hydraulic braking system, the pressure in the control line shall not exceed 11,500 kPa and the pressure in the supplementary line shall be between 1,500 kPa and 1,800 kPa during the brake test.

The test speed is 60 km/h or the maximum design speed of the towed vehicle, whichever is the lower.

Where the braking system is of the inertia type, it shall comply with the conditions laid down in Annex VIII.

3.2.1.3. Requirement relating to tests of category R3, R4 or S2 vehicles

The sum of the forces exerted at the periphery of the braked wheels shall be at least X % of the maximum stationary wheel load.

X = 50 for towed vehicle of categories R3, R4 and S2 with a maximum design speed exceeding 30 km/h

X = 35 for towed vehicles of categories R3a, R4a and S2a with a maximum design speed not exceeding 30 km/h

Where the towed vehicle is fitted with a compressed-air braking system, the pressure in the control line shall not exceed 650 kPa and the pressure in the supply line shall not exceed 700 kPa during the brake test.

The test speed is 60 km or the maximum design speed of the towed vehicle, whichever is the lower.

Where the towed vehicle is fitted with a hydraulic braking system, the pressure in the control line shall not exceed 11,500 kPa and the pressure in the supplementary line shall be between 1,500 kPa and 1,800 kPa during the brake test.

3.2.1.4. Within an axle group, wheel locking on one axle during the Type-0 test procedure is permitted. This requirement shall not be construed as a departure from the requirement of point 6.3.1. of Annex XI concerning wheel locking of directly controlled wheels.

3.2.2. Parking braking system

3.2.2.1. The parking braking system with which the towed vehicle is equipped shall be capable of holding the laden towed vehicle stationary, when separated from the tractor, on an 18% up and down-gradient.

3.2.2.2. The requirements set out in 3.2.2.1. shall be fulfilled even during the cooling period. The cooling period is deemed to be terminated when the brakes have reached a temperature of 10 °C above ambient.

3.2.2.3. Hot and cold parking braking performance test

The test requirement as specified in point 3.1.3.3. apply correspondingly.

3.2.3. Automatic braking system

The automatic braking performance in the event of a failure, as described in points 2.2.1.17. and 2.2.1.18. of Annex I, when testing the laden vehicle from a speed of 40 km/h or 0.8 v_{max} (whichever is lower), shall not be less than 13.5% of the maximum stationary wheel load. Wheel-locking at performance levels above 13.5 % is permitted.

3.3. Response time for vehicles of categories T, C, R and S

3.3.1. Where a vehicle is fitted with a service braking system which is totally or partially dependent on a source of energy other than the muscular effort of the driver, the following requirements shall be satisfied:

3.3.1.1. In an emergency manoeuvre, the time elapsing between the moment when the control device begins to be actuated and the moment when the braking force on the least favourably placed axle reaches the level corresponding to the prescribed performance shall not exceed 0.6 seconds.

3.3.1.2. In the case of vehicles fitted with compressed-air or towed vehicles with hydraulic braking systems or tractors with a hydraulic control line, the requirements of point 3.3.1. are considered to be satisfied if the vehicle complies with the provisions of Annex III.

3.3.1.3. In the case of tractors fitted with hydraulic braking systems, the requirements of point 3.3.1. are considered to be satisfied if, in an emergency manoeuvre, the deceleration of the vehicle, or the pressure at the least favourable brake cylinder, reaches a level corresponding to the prescribed performance within 0.6 seconds.

3.3.1.4. In case of tractors with one braked axle and an automatic engagement of the drive to all other axles during braking, the requirements of point 3.3.1. are considered to be satisfied if, the tractor satisfies both the prescribed stopping distance and the prescribed mean fully developed deceleration for the relevant vehicle category according to point 3.1.1.1., but in this case it is necessary to actually measure both parameters.

Appendix 1

Distribution of braking among the axles of vehicles and requirements for compatibility between tractor and towed vehicle

1. General requirements

1.1. Vehicles of categories T, C, R and S

1.1.1. Vehicles of categories Ta, Ca, R2a, R3a, R4a and S2a with a maximum design speed exceeding 30 km/h shall fulfil the following requirements of this Appendix:

1.1.1.1. the compatibility requirements associated with diagrams 2 and 3, as appropriate, if a special device is used, this shall operate automatically. In the case of trailers with electronically controlled brake force distribution, the requirements of this appendix shall only apply when the trailer is electrically connected to the tractor by the ISO 7638:2003 connector.

1.1.1.2. in the event of a failure of the control of the special device the braking performance specified in point 5 shall be fulfilled for the relevant vehicle.

1.1.1.3. the marking requirements laid down in point 6.

1.1.2. Vehicles of categories Tb, R2b, R3b, R4b and S2b shall meet the relevant requirements of this Appendix. If a special device is used, this shall operate automatically.

1.1.3. However, vehicles of the categories mentioned in point 1.1.1. and those in point 1.1.2. equipped with an anti-lock braking system of category 1 or 2 (tractors) and category A or B (towed vehicles) fulfilling the relevant requirements of Annex XI shall also fulfil all the relevant requirements of this Appendix with the following exceptions:

1.1.3.1. compliance with the adhesion utilization requirements associated with diagram 1 is not required;

1.1.3.2. in the case of tractors and towed vehicles, compliance with the unladen compatibility requirements associated with diagrams 2 and 3 as appropriate, is not required. However, for all load conditions, a braking rate shall be developed between a pressure of 20 kPa and 100 kPa (pneumatic braking systems) and 350 to 1,800 kPa (hydraulic braking systems) or the equivalent digital demand value at the coupling head of the control line(s);

1.1.3.3. vehicles equipped with a special device which automatically controls the distribution of braking among the axles or automatically regulates the braking force according to the load on the axle(s) the requirements of points 5. and 6. shall apply.

1.1.4 Where the vehicle is installed with an endurance braking system, the retarding force shall not be taken into consideration when determining the vehicle performance with respect to the provisions of this Appendix.

1.2. The requirements relating to the diagrams specified in points 3.1.6.1., 4.1. and 4.2., are valid for vehicles with a pneumatic and electrical control line according to point 2.1.4. of Annex I or a hydraulic control line according to point 2.1.5. of Annex I. In all cases, the reference value (abscissa of the diagrams) will be the value of the transmitted pressure or electrical signal respectively in the control line:

1.2.1. For vehicles equipped according to point 2.1.4.1.1. of Annex I, this value will be the actual pneumatic pressure in the control line (p_m);

1.2.2. For vehicles equipped according to point 2.1.4.1.2. or 2.1.4.1.3. of Annex I, this value 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 according to point 2.1.4.1.2. of Annex I (with both pneumatic and electric control lines) shall satisfy the requirements of the diagrams related to both control lines. However, identical braking characteristic curves related to both control lines are not required.

1.2.3. For vehicles equipped according to point 2.1.5.1. of Annex I, this value shall be the actual hydraulic pressure in the control line (p_m).

1.3. Validation of the development of braking force.

1.3.1. At the time of type-approval it shall be checked that the development of braking on an axle of each independent axle group shall be within the following pressure ranges:

1.3.1.1. Laden vehicles:

At least one axle shall commence to develop a braking force when the pressure at the coupling head is within the pressure range 20 to 100 kPa (pneumatic braking systems) and 350 to 1,800 kPa (hydraulic braking systems) respectively or equivalent digital demand value.

At least one axle of every other axle group shall commence to develop a braking force when the coupling head is at a pressure $\leq$ 120 kPa (pneumatic braking systems) and 2,100 kPa (hydraulic braking systems) respectively or equivalent digital demand value.

1.3.1.2. Unladen vehicles:

At least one axle shall commence to develop a braking force when the pressure at the coupling head is within the pressure range 20 to 100 kPa (pneumatic braking systems) and 350 to 1,800 kPa (hydraulic braking systems) respectively or equivalent digital demand value.

1.3.1.3. With the wheel(s) of the axle(s) raised off and free to rotate, apply an increasing brake demand and measure the coupling head pressure corresponding to when the wheel(s) can no longer be rotated by hand. In the case of tractors of category C an alternative procedure

may be used for the validation of the development of braking force (e.g. by removing the tracks). This condition determines the development of the braking force.

2. Symbols

i	=	axle index (i = 1, front axle; i = 2, second axle; etc.)
E	=	wheelbase
E_R	=	distance between coupling point and centre of axle of rigid drawbar towed vehicle and of centre-axle towed vehicle
f_i	=	T_i/N_i, adhesion utilized by axle i
F_i	=	normal reaction of road surface on axle i under static conditions
F_M	=	total normal static reaction of road surface on wheels of tractor
g	=	acceleration due to gravity: g = 9.81 m/s^2
h	=	height above ground of centre of gravity specified by the manufacturer and agreed by the Technical Services conducting the approval test;
J	=	deceleration of vehicle
k	=	theoretical coefficient of adhesion between tyre and road
P	=	mass of vehicle
N_i	=	normal reaction of road surface on axle i under braking
p_m	=	pressure at coupling head of control line
F_R	=	total normal static reaction of road surface on all wheels of towed vehicle
F_{Rmax}	=	value of F_R at maximum mass of towed vehicle
T_i	=	force exerted by the brakes on axle i under normal braking conditions on the road
T_M	=	sum of braking forces at the periphery of all wheels of tractors
T_R	=	sum of braking forces T_i at periphery of all wheels of towed vehicle
z	=	braking rate of vehicle = J/g

3. Requirements for tractors of category T

3.1. Two-axle tractors

3.1.1. For all categories of tractors for k values between 0.2 and 0.8:

$$z \geq 0.10 + 0.85 (k - 0.20)$$

The provisions laid down in points 3.1.1. and 4.1.1. do not affect the requirements of Annex II relating to the braking performance. However, if, in tests made under the provisions of points 3.1.1. and 4.1.1., braking performances are obtained which are

higher than those prescribed in Annex II, the provisions relating to the adhesion utilization curves shall be applied within the areas of diagram 1 defined by the straight lines k = 0.8 and z = 0.8.

3.1.2. For all states of load of the vehicle, the adhesion utilization curve of the rear axle shall not be situated above that for the front axle:

3.1.2.1. for all braking rates between 0.15 and 0.30

This condition is also considered satisfied if, for braking rates between 0.15 and 0.30, the adhesion utilization curves for each axle are situated between two lines parallel to the line of ideal adhesion utilization given by the equation k = z +0.08 as shown in diagram 1 of this Appendix and the adhesion utilization curve for the rear axle for braking rates z > 0.3 complies with the relation:

$z \geq 0.3 + 0.74 (k - 0.38)$.

3.1.3. For tractors authorized to tow vehicles of category R3b, R4b and S2b fitted with compressed-air braking systems:

3.1.3.1. When tested with the energy source stopped, the supply line blocked off, a reservoir of 0.5 litre capacity connected to the pneumatic control line and the system at cut-in and cut-out pressures, the pressure at full application of the braking control device shall be between 650 and 850 kPa at the coupling heads of the supply line and the pneumatic control line, irrespective of the load condition of the vehicle.

3.1.3.2. For vehicles equipped with an electric control line, a full application of the control device of the service braking system shall provide a digital demand value corresponding to a pressure between 650 and 850 kPa (cf ISO 11992:2003 including ISO 11992-2:2003 and its Amd.1:2007).

3.1.3.3. These values shall be demonstrably present in the tractor when the latter is uncoupled from the towed vehicle. The compatibility bands in the diagrams specified in points 3.1.6., 4.1. and 4.2., should not be extended beyond 750 kPa and/or the corresponding digital demand value (see ISO 11992:2003 including ISO 11992-2:2003 and its Amd.1:2007).

3.1.3.4. It shall be ensured that at the coupling head of the supply line, a pressure of at least 700 kPa is available when the system is at cut-in pressure. This pressure shall be demonstrated without applying the service brakes.

3.1.4. For tractors authorized to tow vehicles of category R3b, R4b and S2b fitted with hydraulic braking systems:

3.1.4.1. When tested with the energy source at idling speed and of 2/3 of maximum engine speed, a control line of the towed vehicle simulator (point 3.6. of Annex III) connected to the hydraulic control line. At full application of the braking control device the pressures shall be between 11,500 and 15,000 kPa at the hydraulic control and shall be between 1,500 and 3,500 kPa at the supplementary line, irrespective of the load condition of the vehicle.

3.1.4.2. These values shall be demonstrably present in the tractor when uncoupled from the towed vehicle. The compatibility bands in the diagrams specified in points 3.1.6., 4.1. and 4.2., should not be extended beyond 13,300 kPa.

3.1.5. Verification of the requirements of points 3.1.1. and 3.1.2.

3.1.5.1. In order to verify the requirements of points 3.1.1. and 3.1.2., the manufacturer shall provide the adhesion utilization curves for the front and rear axles calculated by the formulae:

$$f_1 = \frac{T_1}{N_1} = \frac{T_1}{F_1 + z \cdot \frac{h}{E} \cdot P \cdot g}$$

$$f_2 = \frac{T_2}{N_2} = \frac{T_2}{F_2 - z \cdot \frac{h}{E} \cdot P \cdot g}$$

The curves shall be plotted for both the following load conditions:

3.1.5.1.1. Unladen, not exceeding the minimum mass declared by the manufacturer in the information document;

3.1.5.1.2. Laden; where provision is made for several possibilities of load distribution, the one whereby the front axle is the most heavily laden shall be the one considered.

3.1.5.2. If it is not possible, for vehicles with permanent all-wheel drive or in the condition when the all-wheel drive is connected during braking, to carry out the mathematical verification pursuant to point 3.1.5.1., the manufacturer may instead verify by means of a wheel lock sequence test that, for all braking rates between 0.15 and 0.8, lockup of the front wheels occurs either simultaneously with or before the lockup of the rear wheels. This alternative option does not exempt the manufacturer to show compliance with point 3.1.5.1. for the condition when the all-wheel drive is not connected during braking.

3.1.5.2.1. However, for tractors which automatically apply the all-wheel drive when the braking is initiated above a vehicle speed of 20 km/h but not automatically connect the all-wheel drive when the service braking system is applied at speeds ≤ 20 km/h, then it is not required to show compliance with point 3.1.5.1. for the condition when the all-wheel drive is not connected during braking.

3.1.5.3. Procedure to verify the requirements of point 3.1.5.2.

3.1.5.3.1. The wheel lock sequence test shall be conducted on road surfaces with a coefficient of adhesion of not more than 0.3 and of about 0.8 (dry road) from the initial test speeds specified in point 3.1.5.3.2.

3.1.5.3.2. Test speeds:

0.8 v_{max} km/h, but not exceeding 60 km/h for decelerations on low coefficient of friction road surfaces;

0.9 v_{max} for decelerations on high coefficient of friction road surfaces.

3.1.5.3.3. The pedal force applied may exceed the permissible actuation forces pursuant to point 3.2.1.

3.1.5.3.4. Pedal force is applied and increased such that the second wheel on the vehicle shall reach lockup between 0.5 and 1 s after initiating the brake application, until lockup of both wheels on one axle occurs (additional wheels may also lock during the test, e.g. in the case of simultaneous lockup).

3.1.5.4. The tests prescribed in point 3.1.5.2. shall be carried out twice on each road surface. If the result of one test fails, a third, hence decisive test shall be carried out.

3.1.6. Tractors authorized to draw towed vehicles other than rigid drawbar towed vehicles and centre-axle towed vehicles

3.1.6.1. The permissible relationship between the braking rate T_M/F_M and the pressure p_m shall lie within the areas shown on diagram 2 for all pressures between 20 and 750 kPa (in the case of compressed air braking system) and 350 and 13,300 kPa (in the case of hydraulic braking system)

3.2. Tractors with more than two axles

The requirements of point 3.1. shall apply to vehicles with more than two axles. The requirements of point 3.1.2. with respect to wheel lock sequence shall be considered to be met if, in the case of braking rates between 0.15 and 0.30, the adhesion utilized by at least one of the front axles is greater than that utilized by at least one of the rear axles.

4. Requirements for towed vehicles

4.1. For drawbar towed vehicles fitted with compressed-air and hydraulic braking systems:

4.1.1. For drawbar towed vehicles with two axles the following requirements apply:

4.1.1.1. For k values between 0.2 and 0.8:

$z \geq 0.1 + 0.85 (k – 0.2)$

The provisions of point 3.1.1. do not affect the requirements of Annex II relating to the braking performance. However, if, in tests made under the provisions of point 3.1.1. , braking performances are obtained which are higher than those prescribed in Annex II, the provisions relating to the adhesion utilization curves shall be applied within the areas of diagrams 1 of this Annex defined by the straight lines $k = 0.8$ and $z = 0.8$.

4.1.1.2. For all states of load of the vehicle, the adhesion utilization curve of the rear axle shall not be situated above that for the front axle for all braking rates between 0.15

and 0.30. This condition is also considered satisfied if, for braking rates between 0.15 and 0.30, the following two conditions are satisfied:

4.1.1.2.1. the adhesion utilization curves for each axle are situated between two lines parallel to the line of ideal adhesion utilization given by the equations $k = z + 0.08$ and $k = z - 0.08$ as shown in diagram 1

and

4.1.1.2.2. the adhesion utilization curve for the rear axle for braking rates $z \geq 0.3$ complies with the relation $z \geq 0.3 + 0.74 (k – 0.38)$.

4.1.1.3. For the verification of the requirements of points 4.1.1.1. and 4.1.1.2. the procedure should be as that in the provisions of point 3.1.5.

4.1.2. For drawbar towed vehicles with more than two axles the requirements of point 4.1.1. shall apply. The requirements of point 4.1.1. with respect to wheel lock sequence shall be considered to be met if, in the case of braking rates between 0.15 and 0.30, the adhesion utilized by at least one of the front axles is greater than that utilized by at least one of the rear axles.

4.1.3. The permissible relationship between the braking rate T_R/F_R and the pressure pm shall lie within the designated areas in diagram 3 for all pressures between 20 and 750 kPa (pneumatic) and 350 and 13,300 kPa (hydraulic) respectively, in both the laden and unladen states of load.

4.2. For rigid drawbar towed vehicles and centre-axle towed vehicles fitted with compressed-air and hydraulic braking systems:

4.2.1. The permissible relationship between the braking rate T_R/F_R and the pressure p_m shall lie within two areas derived from diagram 3, by multiplying the vertical scale by 0.95. This requirement shall be met at all pressures between 20 and 750 kPa (pneumatic) and 350 and 13,300 kPa (hydraulic) respectively, in both the laden and unladen states of load.

4.3. For drawbar towed vehicles with inertia braking system

4.3.1. The requirements according to point 4.1.1. apply also for drawbar towed vehicles with inertia braking system.

4.3.2. For drawbar towed vehicles with inertia braking system and with more than two axles the requirements according to point 4.1.2. of this Appendix apply.

4.3.3. For the calculation to verify the compliance with the provisions of point 4.1.1.3. the influence of the permissible drawbar force D* (point 10.3.1. of Annex VIII) can be ignored.

5. Requirements to be met in case of failure of the braking distribution system

When the requirements of this Appendix are fulfilled by means of a special device (e.g. controlled mechanically by the suspension of the vehicle), it shall be possible, in the event of the failure of its control, to stop the vehicle under the conditions specified for secondary braking in the case of tractors; tractors authorized to tow a vehicle fitted with compressed-air or hydraulic braking systems, it shall be possible to achieve a pressure at the coupling

head of the control line within the range specified in points 3.1.3. and 3.1.4. In the event of failure of the control of the device on towed vehicles, a service braking performance of at least 30% of that prescribed for the vehicle in question shall be attained.

6. Markings

6.1 Vehicles which meet the requirements of this Appendix by means of a device mechanically controlled by the suspension of the vehicle shall be marked in accordance with the requirements laid down on the basis of Article 17 (2) (k) and (5) of Regulation (EU) No 167/2013 and with the appropriate data to show the useful travel of the device between the positions corresponding to vehicle unladen and laden states, respectively, and any further information to enable the setting of the device to be checked.

6.1.1. When a brake load sensing device is controlled via the suspension of the vehicle by any other means, the vehicle shall be marked with information to enable the setting of the device to be checked.

6.2. When the requirements of this Appendix are met by means of a device which modulates the air or hydraulic pressure in the brake transmission, the vehicle shall be marked to show the axle loads at the ground, the nominal outlet pressures of the device and an inlet pressure of not less than 80 per cent of the maximum design inlet pressure, as declared by the vehicle manufacturer, for the following states of load:

6.2.1. Technically permissible maximum axle load for the axle(s) which control(s) the device;

6.2.2. Axle load(s) corresponding to the unladen mass of the vehicle in running order as stated in the test report for the braking requirements approval;

6.2.3. The axle load(s) designated by the manufacturer to enable the setting of the device to be checked in service if this is (these are) different from the loads specified in points 6.2.1. to 6.2.2.

6.3. The markings referred to in points 6.1. and 6.2. shall be affixed in a visible position in indelible form. An example of the markings for a mechanically controlled device in a vehicle fitted with compressed-air or hydraulic braking system is provided in accordance with the requirements laid down on the basis of Article 34 (3) of Regulation (EU) 167/2013.

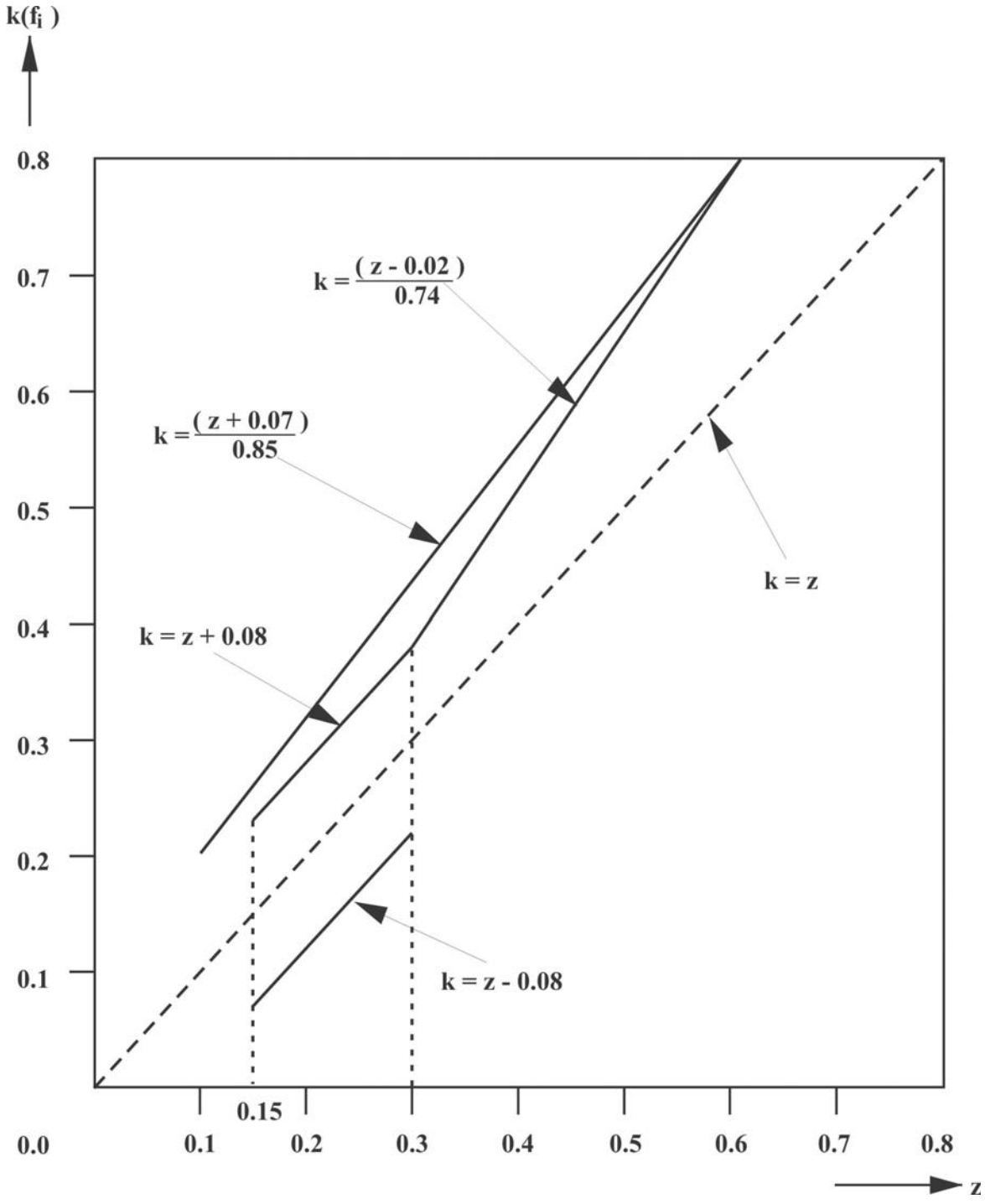
6.4. Electronically controlled brake force distribution systems that cannot fulfil the requirements of points 6.1., 6.2. and 6.3. shall have a self checking procedure of the functions which influence brake force distribution. In addition, when the vehicle is stationary, it shall be possible to carry out the checks laid down in point 1.3.1., by generating the nominal demand pressure associated with the commencement of braking for both the laden and unladen conditions.

7. Vehicle testing

At the time of type-approval, the technical service shall verify conformity with the requirements contained within this Appendix and carry out any further tests considered necessary to this end. The report of any further tests shall be appended to the type-approval report.

Diagram 1

Tractors of category Tb and drawbar towed vehicles of categories R3b, R4b and S2b
(see points 3.1.2.1. and 4.1.1.2.)



Note: The lower limit k = z - 0.08 is not applicable for the adhesion utilization of the rear axle.

Diagram 2

Permissible relationship between braking rate TM/PM and the coupling head pressure p_m for tractors of categories T and C with compressed air or hydraulic braking systems

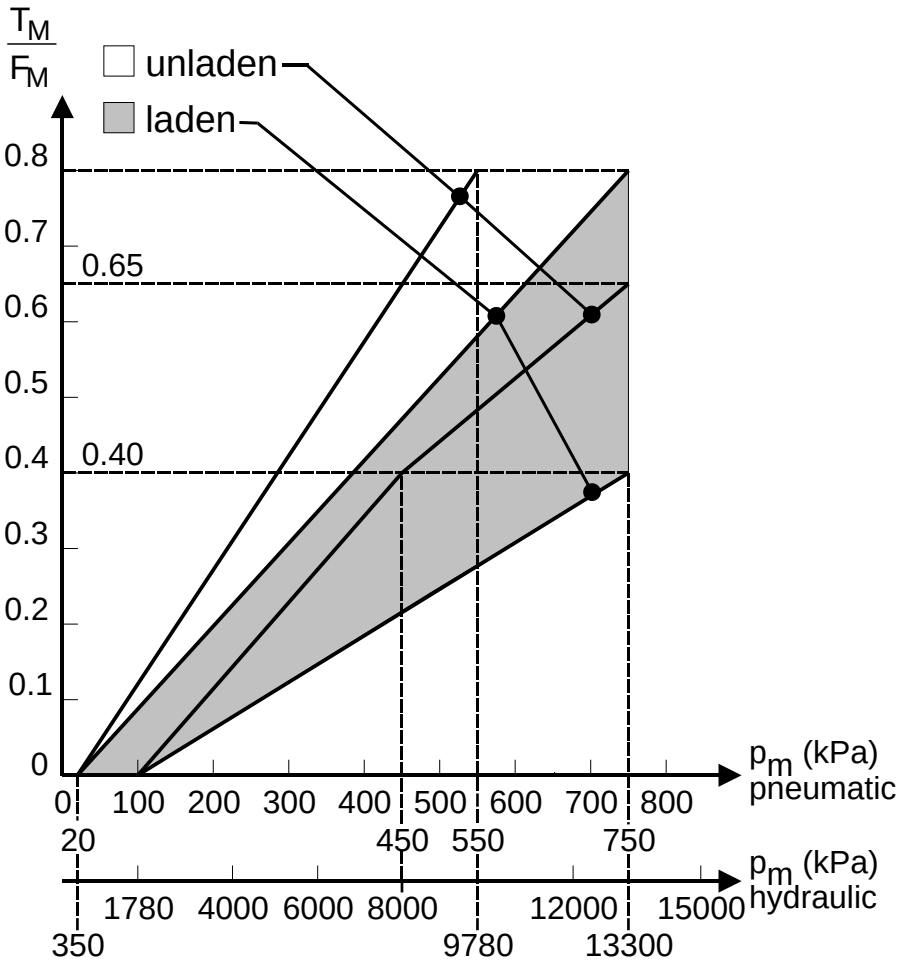
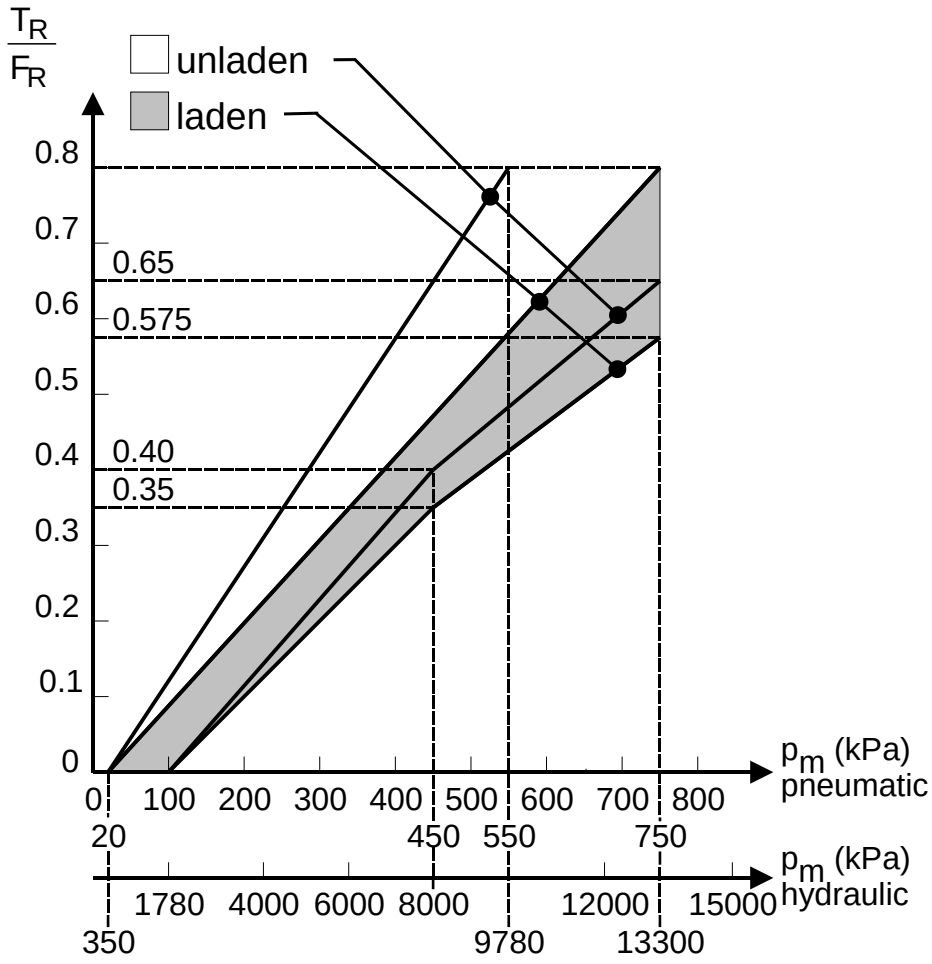


Diagram 3

Permissible relationship between braking rate TR/FR and the coupling head pressure p_m for towed vehicles of categories S2, R3 and R4 with compressed air or hydraulic braking systems



ANNEX III
Requirements applying to the measurement of the response time

1. General Requirements

1.1. The response time for the service braking systems shall be determined with the vehicle stationary, the pressure being measured at the opening of the least favourably placed brake. For vehicles equipped with load sensing valves, these devices shall be set in the 'laden' position.

1.2. During the tests, the stroke of the brake cylinders of the individual axles shall be that corresponding to the most closely adjusted brakes.

1.3. Response times obtained in conformity with points 2.2., 2.3., 2.4., 2.6., 3.3., 3.4., 3.5., 3.6.5., 4.1., 4.5.1., 4.5.2., 4.5.3., 5.3.6., 6.2., shall be rounded to the nearest tenth of second. If the figure representing the hundredth units is 5 or more, the response time is rounded to the upper tenth.

1.4. The diagrams in Appendices 1 and 2 give examples of the correct configuration of the relevant simulators for setting and use.

2. Tractors equipped with compressed-air braking systems

2.1. At the beginning of each test, the pressure in the energy storage device shall be equal to the pressure at which the governor restores the feed to the system. In systems not equipped with a governor (e.g., pressure-limited compressors) the pressure in the energy storage device at the beginning of each test shall be 90% of the pressure specified by the manufacturer and specified in point 1.2.2.1. of Part A of Annex IV, used for the tests prescribed in this annex.

2.2. The response times as a function of the actuating time (t_f) shall be obtained by a succession of full actuations, beginning with the shortest possible actuating time and increasing to a time of about 0.4 seconds. The measured values shall be plotted on a graph.

2.3. The response time to be taken into consideration for the purpose of the test is that corresponding to an actuating time of 0.2 seconds. This response time can be obtained from the graph by interpolation.

2.4. For an actuating time of 0.2 seconds, the time elapsing from the initiation of the braking system control device actuation to the moment when the pressure in the brake cylinder reaches 75% of its asymptotic value shall not exceed 0.6 seconds.

2.5. In the case of tractors having a pneumatic control line for towed vehicles, in addition to the requirements of point 1.1., the response time shall be measured at the extremity of a pipe

2.5 m long with an internal diameter of 13 mm which shall be joined to the coupling head of the control line of the service braking system. During this test, a volume of 385 ±5 cm³ (which is deemed to be equivalent to the volume of a pipe 2.5 m long with an internal diameter of 13 mm and under a pressure of 650 kPa) shall be connected to the coupling head of the supply line. The length and internal diameter of the pipes shall be entered at item 2.4 of the test report .

2.6. The time elapsing from the initiation of brake-pedal actuation to the moment when:

2.6.1. The pressure measured at the coupling head of the pneumatic control line;

2.6.2. The digital demand value in the electric control line measured according to ISO 11992:2003, including ISO 11992-2:2003 and its Amd.1:2007, reaches x per cent of its asymptotic, respectively final, value shall not exceed the times shown in the table below:

x [per cent]	*t [s]*
10	0.2
75	0.4

2.7. In the case of tractors authorized to tow vehicles of category R3 or R4 fitted with compressed-air braking systems, in addition to the requirements in point 2.6., the prescriptions in point 2.2.1.17.2.1. of Annex I shall be verified by conducting the following test:

2.7.1. by measuring the pressure at the extremity of a pipe 2.5 m long with an internal diameter of 13 mm which shall be joined to the coupling head of the supply line;

2.7.2. by simulating a failure of the control line at the coupling head;

2.7.3. by actuating the service braking control device in 0.2 seconds, as described in point 2.3.

3. Tractors equipped with hydraulic braking systems

3.1. The response time tests shall be carried out at an ambient temperature between 15°C and 30°C.

3.2. At the beginning of each test, the pressure in the energy storage device shall be equal to the pressure at which the governor restores the feed to the system. In systems not equipped with a governor (e.g., pressure-limited hydraulic pumps) the pressure in the energy storage device at the beginning of each test shall be 90 % of the pressure specified by the manufacturer and specified in point 1.2.1.2. of Part C of Annex IV, used for the tests prescribed in this annex.

3.3. The response times as a function of the actuating time (t_f) shall be obtained by a succession of full actuations, beginning with the shortest possible actuating time and increasing to a time of about 0.4 seconds. The measured values shall be plotted on a graph.

In the case of a service braking system which is activated with no or only a limited assistance of energy a control force shall be applied which ensures at least the prescribed service braking performance.

3.4. The response time to be taken into consideration for the purpose of the test is that corresponding to an actuating time of 0.2 seconds. This response time can be obtained from the graph by interpolation.

3.5. For an actuating time of 0.2 seconds, the time elapsing from the initiation of the braking system control device actuation to the moment when the pressure in the brake cylinder reaches 75% of its maximum values hall not exceed 0.6 seconds.

In the case of a full powered service braking system where the brake pressure in the brake actuator reaches a temporary maximum pressure which then falls to the mean stabilised pressure. This mean stabilised pressure should be taken for the calculation of the 75% value.

3.6. Tractors equipped with a hydraulic control line for towed vehicles

3.6.1. In addition to the requirements of point 1.1., the response time shall be measured with a towed vehicle simulator (see point 1. of Appendix 2) which shall be joined to the coupling heads of the hydraulic control line and the supplementary line of the tractor.

3.6.2. The towed vehicle simulator shall have the following components and characteristics:

3.6.2.1. Supplementary line towed vehicle simulator

3.6.2.1.1. Supplementary line with a female coupling corresponding to ISO 16028:2006 having an orifice with a diameter of $0.6^{+0.2}$ mm in order to limit its flow during the test.

3.6.2.1.2. Piston accumulator (or equivalent device) complying with the following characteristics and test conditions:

3.6.2.1.2.1. Nominal volume of 1,000 cm³;

3.6.2.1.2.2. Initial precharge pressure of $1{,}000^{\pm 100}$ kPa at a displaced volume of 0 cm³;

3.6.2.1.2.3. Maximum pressure of 1,500 kPa at a displaced volume of $500^{\pm 5}$ cm³.

3.6.2.1.3. The piston accumulator (or equivalent device) is connected with the supplementary line via a connection with an internal diameter of 12.5 mm consisting of a flexible pipe (according to EN853:2007) of 1.0 m length.

3.6.2.1.4. A testing port shall be provided as close as possible to the female ISO 16028:2006 coupling.

3.6.2.1.5. In order to be able to bleed the simulator before and after the test a bleeding device shall be provided.

3.6.2.2. Control line towed vehicle simulator

3.6.2.2.1. Control line with a female coupling corresponding to ISO 5676:1983

3.6.2.2.2. Energy storage device with piston (or equivalent device) complying with the following characteristics and test conditions:

3.6.2.2.2.1. Initial precharge pressure of $500^{\pm 100}$ kPa at a displaced volume of 0 cm³

3.6.2.2.2.2. Intermediate test pressure of $2{,}200^{\pm 200}$ kPa at a displaced volume of $100^{\pm 3}$ cm³

3.6.2.2.2.3. Final pressure of $11{,}500^{\pm 200}$ kPa at a displaced volume of $140^{\pm 5}$ cm³

3.6.2.2.3. The energy storage device with piston (or equivalent device) is connected with the control line via a connection with an internal diameter of 10 mm consisting of a flexible pipe (according to EN853:2007) of 3.0 m and a rigid pipe of 4.5 m length

3.6.2.2.4. Testing ports shall be provided as close as possible to the energy storage device with piston (or equivalent device) and to the female ISO 5676:1983 coupling.

3.6.2.2.5. In order to be able to bleed air from the connection pipes before the test a bleeding device shall be provided

3.6.3. The test shall be performed under the following conditions:

3.6.3.1. the connection pipes shall be bleeded from air before the test;

3.6.3.2. the engine speed of the tractor shall be at 25% above idling speed;

3.6.3.3. the bleeding device of the supplementary line towed vehicle simulator shall be fully opened.

3.6.4. With regard to the measuring of the response time according to points 3.3. and 3.4., the brake control force shall be such to obtain at least a pressure of 11,500 kPa on the coupling head of the control line with the engine running at 25% above idling speed.

3.6.5. For an actuating time of 0.2 seconds, the time elapsing from the initiation of the braking system control device to the moment when the pressure measured at the testing port close to energy storage device with piston (or equivalent device) reaches 75% of its maximum value according to point 3.5. shall not exceed 0.6 seconds.

However, the maximum value relates here to the pressure measured at the testing port instead of the brake pressure as in the case of point 3.5.

4. Towed vehicles equipped with compressed-air braking systems

4.1. The towed vehicle's response times shall be measured without the tractor. To replace the tractor, it is necessary to provide a simulator to which the coupling heads of the supply line, the pneumatic control line and/or the connector of the electric control line are connected.

4.2. The pressure in the supply line shall be 650 kPa.

4.3. The simulator for pneumatic control lines shall have the following characteristics:

4.3.1. It shall have a reservoir with a capacity of 30 litres which shall be charged to a pressure of 650 kPa before each test and which shall not be recharged during each test. At the outlet of the braking control device, the simulator shall incorporate an orifice with a diameter of from 4.0 to 4.3 mm inclusive. The volume of the pipe measured from the orifice up to and including the coupling head shall be 385 ±5 cm³ (which is deemed to be equivalent to the

volume of a pipe 2.5 m long with an internal diameter of 13 mm and under a pressure of 650 kPa). The control line pressures referred to in point 4.3.3. shall be measured immediately downstream of the orifice.

4.3.2. The control device shall be so designed that its performance in use is not affected by the tester.

4.3.3. The simulator shall be set, e.g. through the choice of orifice in accordance with point 4.3.1. in such a way that, if a reservoir of 385 ±5 cm³ is joined to it, the time taken for the pressure to increase from 65 to 490 kPa (10 and 75 per cent respectively of the nominal pressure of 650 kPa) shall be 0.2 ±0.01 seconds. If a reservoir of 1,155 ±15 cm³ is substituted for the above-mentioned reservoir, the time taken for the pressure to increase from 65 to 490 kPa without further adjustment shall be 0.38 ±0.02 seconds. Between these two pressure values, the pressure shall increase in an approximately linear way. These reservoirs shall be connected to the coupling head without using flexible pipes and the connection shall have an internal diameter of not less than 10 mm.

4.3.4. The diagrams in the Appendix 1 give an example of the correct configuration of the simulator for setting and use.

4.4. The simulator for checking the response to signals transmitted via the electric control line shall have the following characteristics:

4.4.1. The simulator shall produce a digital demand signal in the electric control line according to ISO 11992-2:2003 and its Amd.1:2007 and shall provide the appropriate information to the towed vehicle via pins 6 and 7 of the ISO 7638:2003 connector. For the purpose of response time measurement, the simulator may at the manufacturer's request transmit to the towed vehicle information that no pneumatic control line is present and that the electric control line demand signal is generated from two independent circuits (see paragraphs 6.4.2.2.24 and 6.4.2.2.25 of ISO 11992-2:2003 and its Amd.1:2007).

4.4.2. The braking system control shall be so designed that its performance in use is not affected by the tester.

4.4.3. For the purpose of response time measurement the signal produced by the electric simulator shall be equivalent to a linear pneumatic pressure increase from 0.0 to 650 kPa in 0.2 ±0.01 seconds.

4.5. Performance requirements

4.5.1. For towed vehicles with a pneumatic control line the time elapsing between the moment when the pressure produced in the control line by the simulator reaches 65 kPa and the moment when the pressure in the brake actuator of the towed vehicle reaches 75 per cent of its asymptotic value shall not exceed 0.4 seconds.

4.5.1.1. Towed vehicles equipped with a pneumatic control line and having electric control transmission shall be checked with the electrical power supplied to the towed vehicle via the ISO 7638:2003 connector (5 or 7 pin).

4.5.2. For towed vehicles with an electric control line the time elapsing between the moment when the signal produced by the simulator exceeds the equivalent of 65 kPa and the

moment when the pressure in the brake actuator of the towed vehicle reaches 75% of its asymptotic value shall not exceed 0.4 seconds.

4.5.3. In the case of towed vehicles equipped with a pneumatic and an electric control line, the response time measurement for each control line shall be determined independently according to the relevant procedure described in points 4.5.1.1. and 4.5.2.

5. Towed vehicles equipped with hydraulic braking systems

5.1. The tests shall be carried out at an ambient temperature between 15°C and 30°C.

5.2. The response times of the towed vehicle shall be measured without a tractor. In order to simulate the tractor, it is necessary to provide a tractor simulator to which the coupling heads of the control line and the supplementary line are connected. If the towed vehicle is equipped with an electrical connector as specified in point 2.1.5.1.3. of Annex I, this connector shall also be connected to the tractor simulator (see point 2. of Appendix 2).

5.3. The tractor simulator shall have the following characteristics:

5.3.1. The tractor simulator shall be fitted with the types of connections as specified in points 2.1.5.1.1. to 2.1.5.1.3. of Annex I with regard to the tractor.

5.3.2. When the tractor simulator is activated (e. g. by an electrical switch):

5.3.2.1. a pressure of $11{,}500\ ^{+500}$ kPa shall be generated on the coupling head of the control line,

5.3.2.2. a pressure of $1{,}500^{+}\ ^{300}$ kPa shall be present on the coupling head of the supplementary line.

5.3.3. When the control line of the towed vehicle is not connected, the tractor simulator shall be capable of generating a pressure of 11,500 kPa at the coupling head of the control line within 0.2 seconds after it was activated (e.g. by an electrical switch).

5.3.4. The hydraulic fluid used in the tractor simulator shall have a viscosity of $60^{\pm 3}$ mm²/s at a temperature of $40^{\pm 3}$°C (e.g. hydraulic fluid according to SAE 10W30). During the tractor simulator test the temperature of the hydraulic fluid shall not exceed 45°C.

5.3.5. If the towed vehicle is equipped with hydraulic energy storage devices to comply with the requirements for the service braking system, the energy storage devices shall be charged prior to the response time measurements to a pressure as mentioned by the manufacturer in the test report to achieve the minimum prescribed service braking performance.

5.3.6. When the tractor simulator is connected to the control line of the towed vehicle simulator (as specified in point 3.6.2.) the tractor simulator shall be calibrated in such a way that the time elapsing from the activation of the tractor simulator and the moment when the pressure in the energy storage device with piston (or equivalent device) of the control line of the towed vehicle simulator reaches 11,500 kPa shall be $0.6^{+0.1}$ seconds. To achieve this performance the flow of the tractor simulator shall be adjusted (e.g. by a flow regulator). The connection pipes of the control line of the towed vehicle simulator shall be bleeded from air before this calibration.

5.3.7. The control device of the tractor simulator shall be so designed that its performance is not effected by the tester.

5.4. Performance requirements

5.4.1. When the calibrated tractor simulator (see point 5.3.6.) is connected with the towed vehicle, the time elapsing between the moment when the tractor simulator is activated (e.g. by an electrical switch) and the moment when the pressure in the least favourable brake actuator reaches 75 % of its maximum value shall not exceed 0.6 seconds.

In the case of a service braking system, where the brake pressure in the brake actuator reaches a temporary maximum pressure which then falls to the mean stabilised pressure, the mean stabilised pressure should be taken for the calculation of the 75% value.

6. Tractors equipped with service braking system using spring brakes

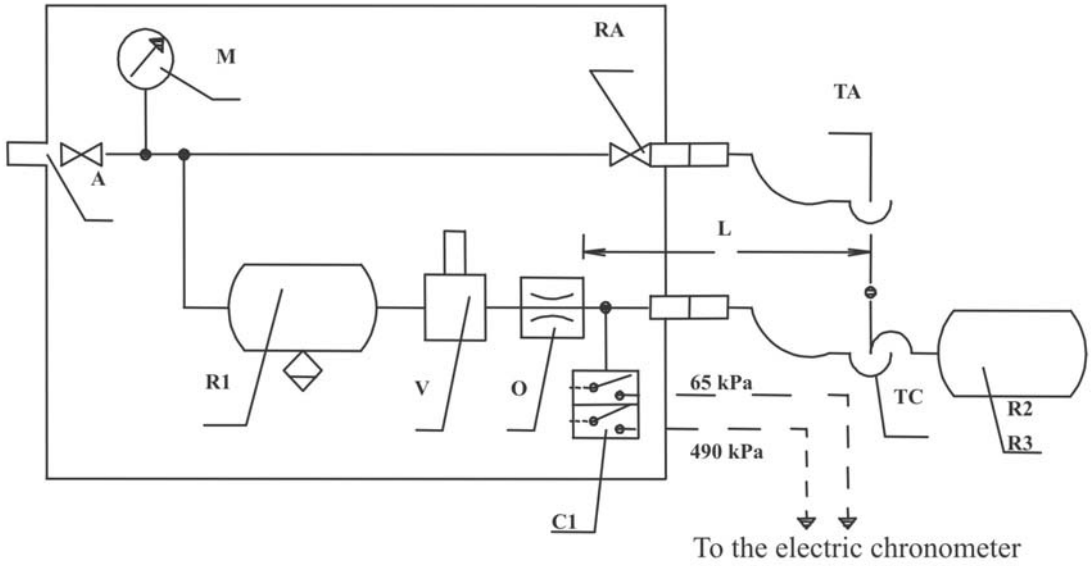
6.1. The response time measurement has to be carried out with the spring brakes adjusted as closely as possible. The initial pressure in the spring compression chamber, corresponding to this testing requirement, shall be specified by the manufacturer.

6.2. The time elapsing from the actuation of the service brake control device (brakes fully released) to the moment when the pressure in the spring compression chamber of the least favourable brake cylinder reaches a pressure corresponding to 75% of the prescribed braking performance shall not exceed 0.6 seconds.

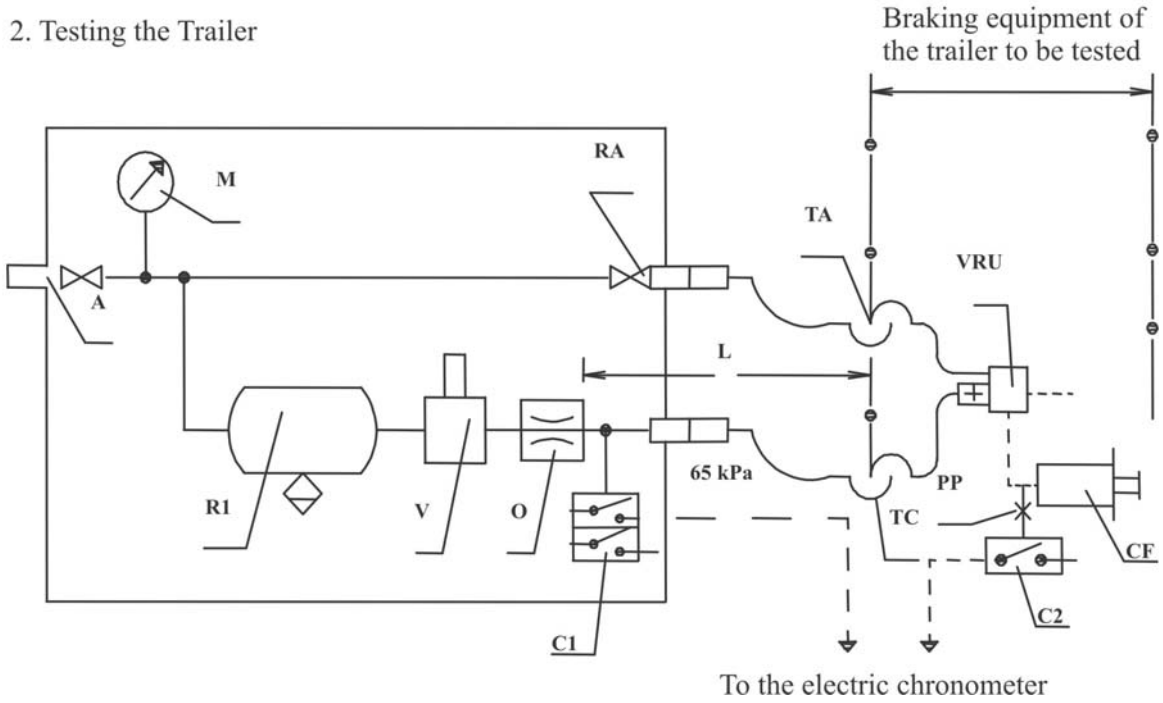
Appendix 1

Examples of pneumatic simulators

1. Setting the Simulator



2. Testing the Trailer



A= supply connection with shut-off valve

C1 = pressure switch in the simulator, set at 65 kPa and at 490 kPa

C2 = pressure switch to be connected to the brake actuator of the towed vehicle, to operate at 75 per cent of the asymptotic pressure in the brake actuator CF

CF = brake cylinder

L = line from orifice O up to and including its coupling head TC, having an inner volume of 385 ± 5 cm^3 under a pressure of 650 kPa

M = pressure gauge

O = orifice with a diameter of not less than 4 mm and not more than 4.3 mm

PP = pressure test connection

R1 = 30 litre air reservoir with drain valve

R2 = calibrating reservoir, including its coupling head TC, to be 385 ± 5 cm^3

R3 = calibrating reservoir, including its coupling head TC, to be 1,155 ± 15 cm^3

RA = shut-off valve

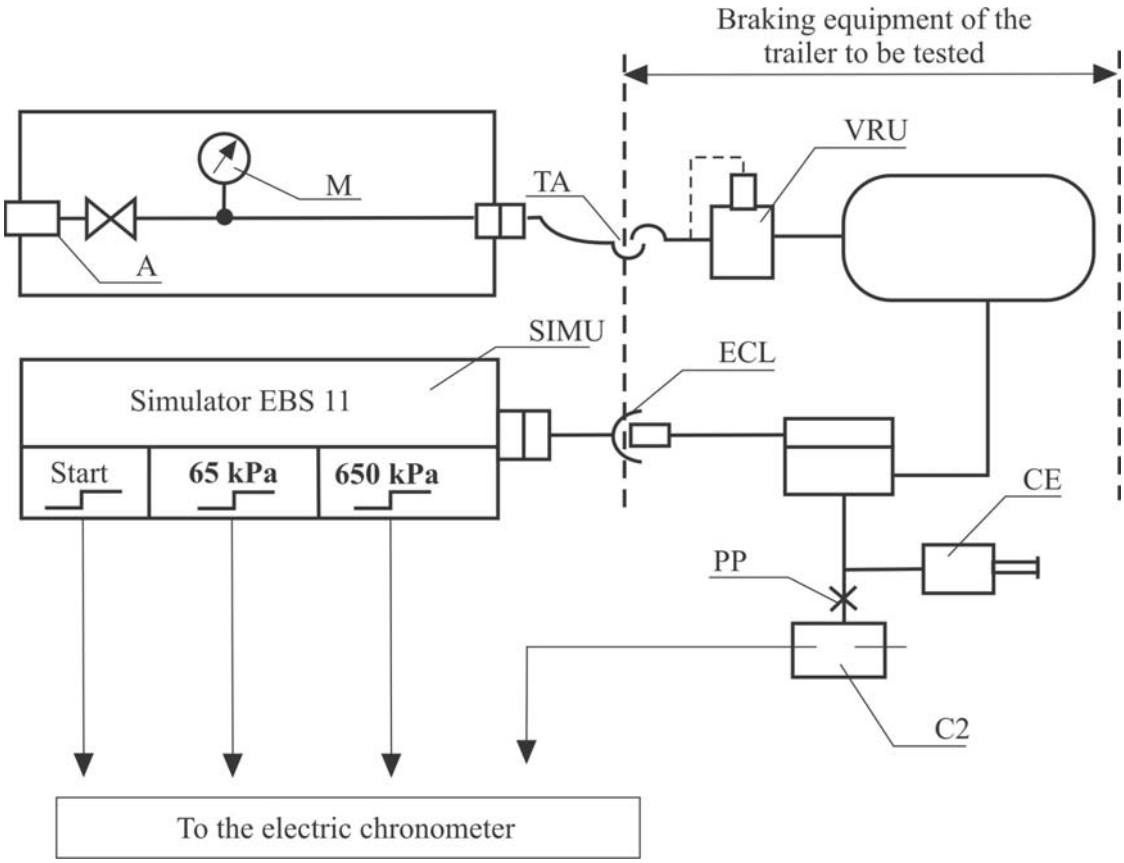
TA = coupling head, supply line

V = braking system control device

TC = coupling head, control line

VRU = emergency relay valve

3. Example of a simulator for electric control lines



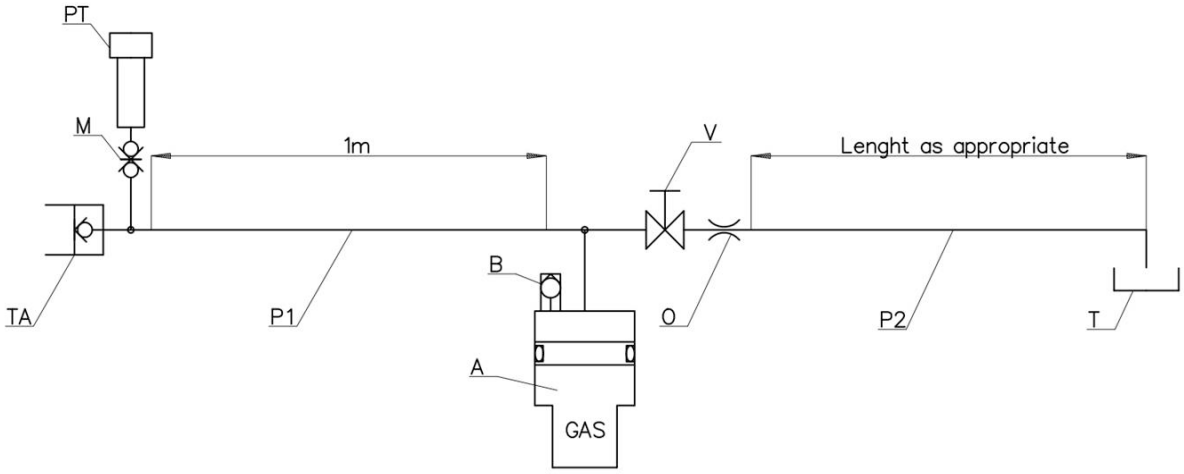
ECL	=	Electric Control Line corresponding to ISO 7638
SIMU	=	Simulator of Byte 3,4 of EBS 11 according to ISO 11992 with output signals at start, 65 kPa and 650 kPa
A	=	Supply connection with shut-off valve
C2	=	Pressure switch to be connected to the brake actuator of the towed vehicle, to operate at 75 per cent of the asymptotic pressure in the brake actuator CF
CF	=	Brake cylinder
M	=	Pressure gauge
PP	=	Pressure test connection
TA	=	Coupling head, supply line
VRU	=	Emergency relay valve

Appendix 2

Examples of hydraulic simulators

1. Towed vehicle simulator

1.1. Supplementary line towed vehicle simulator



TA = coupling head, supplementary line (female coupling ISO 16028:2006)

M = pressure test port

PT = pressure transducer

P1 = flexible pipe acc. to EN853:2007 with internal diameter 12.5 mm

A = hydraulic accumulator (volume: 1000 cm^3, pre-charge pressure: 1000 kPa)

B = bleeding screw

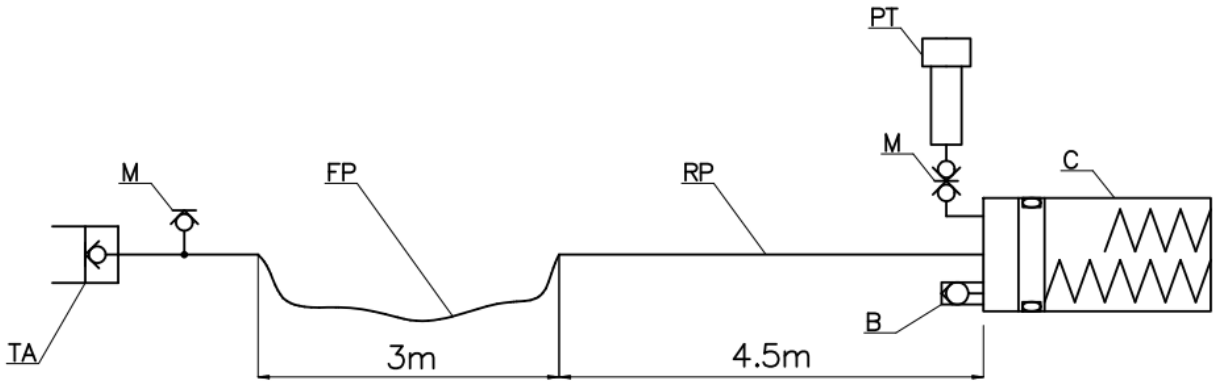
V = bleeding device

O = orifice

P2 = flexible pipe with internal diameter 10 mm

T = return to tractor tank

1.2. Control line towed vehicle simulator



TA = coupling head, control line (female coupling ISO 5676:1983)

M = port for pressure gauge or pressure transducer

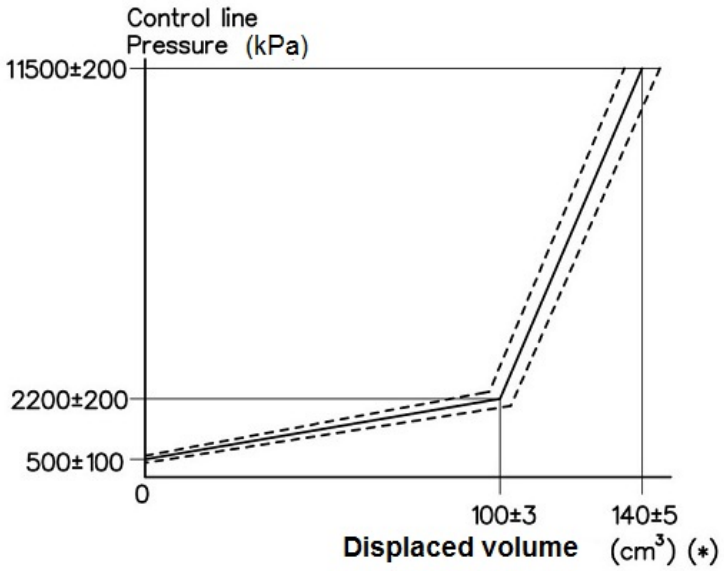
FP = flexible pipe acc. to EN853:2007 with internal diameter 10 mm

RP = rigid pipe with internal diameter 10 mm

PT = pressure transducer

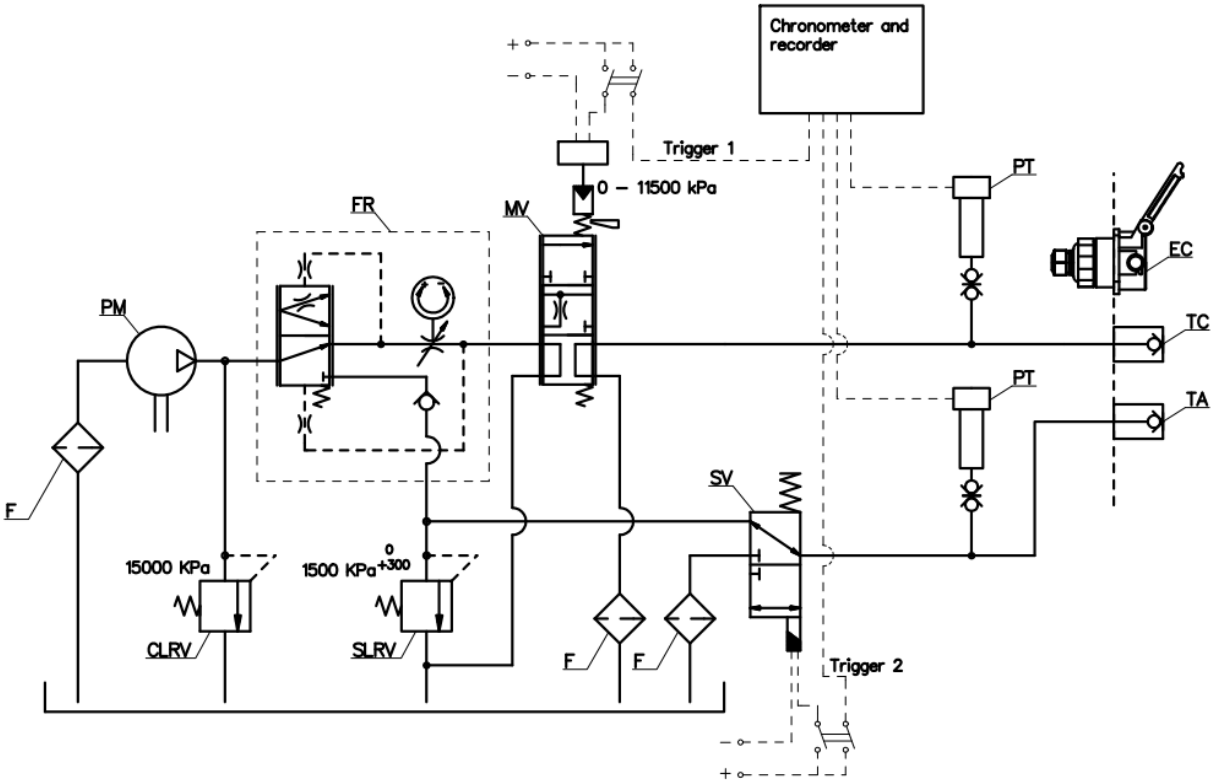
B = bleeding screw

C = cylinder/s (*)



(*) The displaced volume can be obtained with one or more cylinders

2. Tractor simulator



F = filters

PM = pump

PT = pressure transducers

CLRV = control line relief valve

SLRV = supplementary line relief valve

SV = 3 way solenoid valve

FR = flow regulator

MV = proportional modulation valve

TA = coupling head, supplementary line (male coupling ISO 16028:2006)

TC = coupling head, control line (male coupling ISO 5676:1983)

EC = electrical connection (female ISO 7638:2003)

ANNEX IV

Requirements applying to energy sources and energy storage devices of braking systems and trailer braking couplings and to vehicles fitted with them

1. Definitions

For the purposes of this Annex:

1.1. 'hydraulic or pneumatic braking system with stored energy' means a braking system where energy is supplied by a hydraulic fluid or air under pressure, stored in one or more energy storage devices fed from one or more pressure pumps or compressor(s) each fitted with a means of limiting the pressure to a maximum value (specified by the manufacturer).

A. Compressed-air braking systems

1. Capacity of energy storage devices (Energy reservoirs)

1.1. General requirements

1.1.1. Vehicles on which the operation of the braking system depends on the use of compressed air shall be fitted with reservoirs of a capacity meeting the requirements laid down in points 1.2. and 1.3.

1.1.2. However, the reservoirs shall not be required to be of a prescribed capacity if the braking system is such that in the absence of any energy reserve it is possible with the service braking system control device to achieve a braking performance at least equal to that prescribed for the secondary braking system.

1.1.3. When verifying compliance with the requirements laid down in points 1.2. and 1.3. the brakes shall be adjusted as closely as possible.

1.2. Vehicles of category T

1.2.1. The air brake reservoirs of vehicles shall be so designed that after eight full-stroke actuations of the service braking system control device, the pressure remaining in the air brake reservoir shall be not less than the pressure required to obtain the specified secondary braking performance.

1.2.2. During the test, the following requirements shall be satisfied:

1.2.2.1. The initial pressure in the reservoirs shall be that indicated by the manufacturer. This pressure shall be such as to enable the prescribed performance for the service braking system to be achieved. The initial pressure shall be stated in the information document.

1.2.2.2. The reservoir or reservoirs shall not be replenished; in addition, the reservoir or reservoirs of auxiliary equipment shall be isolated.

1.2.2.3. In the case of vehicles authorised to tow a vehicle, the supply line shall be blocked off and a reservoir of 0.5 litre capacity shall be connected to the control line. The pressure in this reservoir shall be exhausted before each actuation of the brakes. After the test referred to in point 1.2.1. the pressure in the control line shall not be less than one half of the pressure obtained at the first brake application.

1.3. Vehicles of categories R and S

1.3.1. Reservoirs fitted to towed vehicles shall be such that after eight full-stroke actuations of the tractor's service braking system, the pressure supplied to the operating parts using it does not fall below a level equivalent to one-half of the figure obtained at the first brake application and without actuating either the automatic or the parking braking system of the towed vehicle.

1.3.2. During the test, the following requirements shall be satisfied:

1.3.2.1. The pressure in the reservoirs at the beginning of the test shall be 850 kPa.

1.3.2.2. The supply line shall be blocked off; in addition, the auxiliary equipment reservoirs shall be isolated.

1.3.2.3. The reservoir shall not be replenished during the test.

1.3.2.4. At each brake application, the pressure in the control line shall be 750 kPa.

1.3.2.5. At each brake application, the digital demand value in the electric control line shall be corresponding to a pneumatic pressure of 750 kPa.

2. Capacity of energy sources

2.1. General provisions

Compressors shall satisfy the requirements laid down in the following points:

2.2. Symbols specific to this section

2.2.1. p_1 the pressure corresponding to 65 % of the pressure p_2 referred to in point 2.2.2.

2.2.2. p_2 is the value specified by the manufacturer and referred to in point 1.2.2.1.

2.2.3. t_1 is the time required for the relative pressure to rise from 0 to p_1; t_2 is the time required for the relative pressure to rise from 0 to p_2.

2.3. Conditions of measurement

2.3.1. In all cases the speed of the compressor shall be that obtained when the engine is running at the speed corresponding to its maximum power or at the speed allowed by the governor.

2.3.2. The auxiliary equipment reservoirs shall be isolated during the tests for determining the periods t_1 and t_2.

2.3.3. On vehicles constructed to tow vehicles, the towed vehicle shall be represented by an air reservoir whose maximum relative pressure p (expressed in kPa/100) is that which can be supplied through the feed circuit of the tractor and whose volume V (expressed in litres) is given by the formula $p \times V = 20 R$ (R being the permissible maximum mass, expressed in tons, on the axles of the towed vehicle).

2.4. Interpretation of results

2.4.1. The time t_1 recorded for the least favoured energy storage device shall not exceed:

2.4.1.1. three minutes in the case of vehicles to which the coupling of a towed vehicle is not authorised;

2.4.1.2. six minutes in the case of vehicles to which the coupling of a towed vehicle is authorised.

2.4.2. The time t_2 for the least efficient reservoir shall not exceed:

2.4.2.1. six minutes in the case of vehicles to which the coupling of a towed vehicle is not authorised;

2.4.2.2. nine minutes in the case of vehicles to which the coupling of a towed vehicle is authorised.

2.5. Additional test

2.5.1. When the vehicle is equipped with an auxiliary equipment reservoir or reservoirs with a total capacity exceeding 20 % of the total capacity of the brake reservoirs, an additional test shall be carried out during the course of which there shall be no interference with the functioning of the valves controlling the filling of the auxiliary equipment reservoir(s). A check shall be made during the course of this test that the period t_3 required to bring about a rise in the pressure in the brake reservoirs from 0 to p_2 is less than:

2.5.1.1. eight minutes in the case of vehicles to which the coupling of a towed vehicle is not authorised

2.5.1.2. eleven minutes in the case of vehicles to which the coupling of a towed vehicle is authorised.

2.5.2. The test shall be performed in the conditions prescribed in points 2.3.1. and 2.3.3.

2.6. Tractors

2.6.1. Vehicles to which the coupling of a towed vehicle is authorised shall also comply with the above requirements for vehicles not so authorised. In that case, the tests in points 2.4.1, 2.4.2 and 2.5.1 shall be conducted without the reservoir mentioned in item 2.3.3.

3. Pressure test connections

3.1. A pressure test connection shall be fitted at the closest readily accessible position to the least efficient reservoir within the meaning of point 2.4.

3.2. The pressure test connections shall comply with clause 4 of ISO standard 3583-1984.

B. VACUUM BRAKING SYSTEMS

1. Capacity of energy storage devices (energy reservoirs)

1.1. General

1.1.1. Vehicles on which the operation of the braking system requires the use of a vacuum shall be equipped with reservoirs of a capacity meeting the requirements laid down in points 1.2. and 1.3.

1.1.2. However, the reservoirs shall not be required to be of a prescribed capacity if the braking system is such that in the absence of any energy reserve it is possible to achieve a braking performance at least equal to that prescribed for the secondary braking system.

1.1.3. In verifying compliance with the requirements laid down in points 1.2. and 1.3. , the brakes shall be adjusted as closely as possible.

1.2. Vehicles of category T and C

1.2.1. The reservoirs of agricultural vehicles shall be such that it is still possible to achieve the performance prescribed for the secondary braking system:

1.2.1.1. after eight full-stroke actuations of the service braking system control device where the energy source is a vacuum pump; and

1.2.1.2. after four full-stroke actuations of the service braking system control device where the energy source is the engine.

1.2.2. Testing shall be performed in conformity with the following requirements:

1.2.2.1. The initial energy level in the reservoir(s) shall be that specified by the manufacturer. It shall be such as to enable the prescribed service-braking performance to be achieved and shall correspond to a vacuum not exceeding 90 % of the maximum vacuum furnished by the energy source. The initial energy level shall be stated in the information document.

1.2.2.2. The reservoir(s) shall not be fed; in addition, any reservoir(s) for auxiliary equipment shall be isolated.

1.2.2.3. In the case of agricultural vehicles authorised to tow a towed vehicle, the supply line shall be blocked off and a reservoir of 0.5 litre capacity shall be connected to the control line. After the test referred to in point 1.2.1., the vacuum level provided at the control line shall not have fallen below a level equivalent to one-half of the figure obtained at the first brake application.

1.3. Vehicles of categories R1, R2 and S1

1.3.1. The reservoir(s) with which towed vehicles are equipped shall be such that the vacuum level provided at the user points shall not have fallen below a level equivalent to one-half of the value obtained at the first brake application after a test comprising four full-stroke actuations of the towed vehicle's service braking system.

1.3.2. Testing shall be performed in conformity with the following requirements:

1.3.2.1. The initial energy level in the reservoir(s) shall be that specified by the manufacturer. It shall be such as to enable the prescribed service braking performance to be achieved. The initial energy level shall be stated in the information document.

1.3.2.2. The reservoir(s) shall not be fed; in addition, any reservoir(s) for auxiliary equipment shall be isolated.

2. Capacity of energy sources

2.1. General

2.1.1. Starting from the ambient atmospheric pressure, the energy source shall be capable of achieving in the reservoir(s) in three minutes the initial level specified in point 1.2.2.1. In the case of a vehicle to which the coupling of a towed vehicle is authorised, the time taken to achieve that level in the conditions specified in point 2.2. shall not exceed six minutes.

2.2. Conditions of measurement

2.2.1. The speed of the vacuum source shall be:

2.2.1.1. Where the vacuum source is the vehicle engine, the engine speed obtained with the vehicle stationary, the neutral gear engaged and the engine idling;

2.2.1.2. where the vacuum source is a pump, the speed obtained with the engine running at 65 % of the speed corresponding to its maximum power output; and

2.2.1.3. where the vacuum source is a pump and the engine is equipped with a governor, the speed obtained with the engine running at 65 % of the maximum speed allowed by the governor.

2.2.2. Where it is intended to couple to the vehicle a towed vehicle whose service braking system is vacuum-operated, the towed vehicle shall be represented by an energy storage device having a capacity V in litres determined by the formula:

$V = 15 R$

where R is the maximum permissible mass, in metric tonnes, on the axles of the towed vehicle.

C. Hydraulic braking systems with stored energy

1. Capacity of energy storage devices

1.1. General

1.1.1. Vehicles on which the operation of the braking system requires the use of stored energy provided by hydraulic fluid under pressure shall be equipped with energy storage devices of a capacity meeting the requirements laid down in points 1.2. and 1.3.

1.1.2. However, the energy storage devices shall not be required to be of a prescribed capacity if the braking system is such that in the absence of any energy reserve it is possible with the service braking system control device to achieve a braking performance at least equal to that prescribed for the secondary braking system.

1.1.3. In verifying compliance with the requirements laid down in points 1.2.1., 1.2.2. and 2.1., the brakes shall be adjusted as closely as possible.

1.2. Vehicles of category T and C

1.2.1. Vehicles equipped with a hydraulic braking system with stored energy shall meet the following requirements:

1.2.1.1. After eight full-stroke actuations of the service braking system control device, it shall still be possible to achieve, on the ninth application, the performance prescribed for the secondary braking system.

1.2.1.2. Testing shall be performed in conformity with the following requirements:

1.2.1.2.1. Testing shall commence at a pressure that may be specified by the manufacturer but is not higher than the cut-in pressure.

1.2.1.2.2. The energy storage devices shall not be fed; in addition, any energy storage devices for auxiliary equipment shall be isolated.

1.2.2. Tractors equipped with a hydraulic braking system with stored energy which cannot meet the requirements of point 2.2.1.4.1. of Annex I shall be deemed to satisfy that point if the following requirements are met:

1.2.2.1. After any single transmission failure it shall still be possible after eight full-stroke actuations of the service braking system control device, to achieve, at the ninth application, at least the performance prescribed for the secondary braking system or, or, where performance prescribed for the secondary braking system requiring the use of stored energy is achieved by a separate control device, it shall still be possible after eight full-stroke actuations to achieve, at the ninth application, the residual performance prescribed in paragraph 3.1.4 of Annex II of this Regulation.

1.2.2.2. Testing shall be performed in conformity with the following requirements:

1.2.2.2.1. With the energy source stationary or operating at a speed corresponding to the engine idling speed, any transmission failure may be induced. Before inducing such a failure the energy storage device(s) shall be at a pressure that may be specified by the manufacturer but not exceeding the cut-in pressure.

1.2.2.2.2. The auxiliary equipment and its energy storage devices, if any, shall be isolated.

1.3. Vehicles of categories R and S

1.3.1. If towed vehicles are equipped with energy storage devices (energy reservoirs), they shall be such that, after eight full-stroke actuations of the tractor's service braking system, the energy level supplied to the operating members using the energy, does not fall below a level equivalent to one-half of the figure obtained at the first brake application and without actuating either the automatic or the parking braking system of the towed vehicle.

1.3.2. During the test, the following requirements shall be satisfied:

1.3.2.1. The pressure in the energy storages at the beginning of the test shall be 15,000 kPa;

1.3.2.2. The supplementary line shall be stopped; in addition, any energy storage device(s) for auxiliary equipment shall be isolated;

1.3.2.3. The energy storage device(s) shall not be replenished during the test.

1.3.2.4. At each brake application, the pressure in the hydraulic control line shall be 13,300 kPa.

2. Capacity of hydraulic fluid energy sources

The energy sources shall meet the requirements set out in the following points:

2.1. Vehicles of category T and C

2.1.1 Symbols

2.1.1.1. 'p_1` represents the maximum system operational pressure (cut-out pressure) in the energy storage devices specified by the manufacturer.

2.1.1.2. 'p_2` represents the pressure after four full-stroke actuations with the service braking system control device, starting at p_1, without having fed the energy storage devices.

2.1.1.3. 't` represents the time required for the pressure to rise from p_2 to p_1 in the energy storage devices without application of the service braking system control device.

2.1.2. Conditions of measurement

2.1.2.1. During the test to determine the time t, the feed rate of the energy source shall be that obtained when the engine is running at the speed corresponding to its maximum power or at the speed allowed by the governor.

2.1.2.2. During the test to determine the time t, energy storage devices for auxiliary equipment shall not be isolated other than automatically.

2.1.3. Interpretation of results

The time t shall not exceed30 s in the case of tractors.

2.2. Tractors equipped with a hydraulic control line for towed vehicles

2.2.1. To determine the feed rate of the energy source the supplementary line towed vehicle simulator as prescribed in paragraph 3.6.2.1. of Annex III to this Regulation shall be connected to the coupling head of the hydraulic supplementary line of the tractor.

2.2.2. The test shall be performed under the following conditions:

2.2.2.1. The test shall be carried out at an ambient temperature between 15°C and 30°C.

2.2.2.2. The supplementary line towed vehicle simulator shall be connected to the coupling head of the supplementary line before the test with engine not running.

2.2.2.3. The engine speed of the tractor during the test shall be 25% above idling speed.

2.2.2.4. The parking brake control of the tractor shall be fully released during the test.

2.2.3. With the engine running and the bleeding device fully closed, the time elapsing when the pressure at the testing port close to the female ISO 16028:2006 coupling rises from 300 kPa to 1,500 kPa shall not exceed 2.5 seconds.

2.3. Vehicles of category R and S

If a towed vehicle using an energy storage device to assist the service braking system and such an energy storage device is recharged by the control line pressure during application of the service braking and/or by an energy source fitted on the towed vehicle, the following requirements shall be met:

2.3.1. The energy source shall be powered by the tractor simulator according to Appendix 2 of Annex III via the electrical connector conforming to ISO 7638:2003.

2.3.2. Symbols

2.3.2.1. 'p_{R1}` represents the maximum system operational pressure (cut-out pressure) in the energy storage device specified by the manufacturer.

2.3.2.2. 'p_{R2}` represents the pressure after four full-stroke actuations of the tractor's service braking system control device.

2.3.2.3. 't_R' represents the time required for the pressure to rise from p_{R2} to p_{R1} in the energy storage device without application of the service braking system control device of the tractor.

2.3.3. Conditions of measurement

During the test to determine the time t_R the following requirements shall be satisfied:

2.3.3.1. The pressure in the energy storage device at the beginning of the test shall be the pressure 'p_{R1}`.

2.3.3.2. The service braking system shall be operated four times by the control line of the tractor simulator.

2.3.3.3. At each brake application, the pressure in the control line shall be 13,300 kPa.

2.3.3.4. Energy storage devices for auxiliary equipment shall not be isolated other than automatically.

2.3.3.5. The valve feeding the energy storage device by the pressure of the control line shall be closed during the test.

2.3.4. Interpretation of results

The time t_R shall not exceed 4 min.

3. Characteristics of alarm devices

With the engine stationary and commencing at a pressure that may be specified by the manufacturer but does not exceed the cut-in pressure, the alarm device shall not operate following two full-stroke actuations of the service braking system control device.

ANNEX V
Requirements applying to spring brakes and to vehicles fitted with them

1. Construction, fitting and inspection requirements

1.1. Definitions

For the purposes of this Annex:

1.1.1. ‘spring braking systems’ means braking systems for which the energy required for braking is supplied by one or more springs acting as an energy storage device ;

1.1.2. ‘pressure’ means negative pressure if the compression of the springs is obtained by means of a vacuum device.

2. General requirements

For the purposes of this Annex, the maximum design speed is meant to be in the forward direction of the vehicle travel, unless otherwise explicitly mentioned.

2.1. A spring braking system shall not be used as a service braking system except under the condition specified in point 2.2. However, in the event of a failure in a part of the transmission of the service braking system, a spring braking system may be used to achieve the residual performance prescribed in point 3.1.4. of Annex II provided that the driver can graduate this action.

2.1.1. Spring brakes may be used as secondary braking system independently of the vehicle maximum design speed, provided that the driver can graduate their braking action and that the performance requirements of Annex II are fulfilled.

Exceptionally, in the case of vehicles with maximum design speed not exceeding 30 km/h that use spring brakes, which control is of the ON/OFF type (e.g. a knob or a switch) and do not allow the driver to graduate the braking action, as secondary braking system, the following requirements shall be met:

2.1.1.1. The driver shall be able to actuate the spring brakes control from own driving seat, while keeping at least one hand on the steering control.

2.1.1.2. The braking performance prescribed in Annex II to this Regulation shall be fulfilled.

2.1.1.3. The prescribed performance shall be obtained without deviation of the vehicle from its course, without abnormal vibrations and without wheel-locking.

2.1.2. Vacuum spring brakes shall not be used for towed vehicles.

The energy necessary to compress the spring in order to release the brake shall be supplied and controlled by the control device actuated by the driver

2.2. On vehicles with a maximum design speed not exceeding 30 km/h, a spring braking system may be used as a service braking system, provided that the driver can graduate its braking action.

In the case of a spring braking system used as a service braking system, the following additional requirements shall be fulfilled:

2.2.1. response time requirements as laid down in point 5. of Annex III;

2.2.2. with the spring brakes adjusted as closely as possible, it shall be possible to actuate :

2.2.2.1. the brake 10 times within a minute with the engine running at idle speed (brake applications distributed evenly within this period);

2.2.2.2. the service braking system 6 times starting with a pressure not higher than the cut-in pressure of the energy source. During this test the energy storage devices shall not be fed. In addition, any energy storage for auxiliary equipment shall be isolated.

2.2.3. The spring brakes shall be designed in such a way that they are not subject to failure under fatigue. Thus, the manufacturer shall provide the Technical Service with appropriate endurance test reports.

2.3. A small variation in any of the pressure limits which may occur in the spring compression chamber feed circuit shall not cause a significant variation in the braking force.

2.4. The following requirements shall apply to tractors equipped with spring brakes:

2.4.1. The feed circuit to the spring compression chamber shall either include an own energy reserve or shall be fed from at least two independent energy reserves. The towed vehicle’s pneumatic supply line or hydraulic supplementary line may be branched from this feed line under the condition that a pressure drop in the lines mentioned above shall not be able to apply the spring brake actuators.

2.4.2. Auxiliary equipment may only draw its energy from the feed line for the spring brake actuators under the condition that its operation, even in the event of damage to the energy source, cannot cause the energy reserve for the spring brake actuators to fall below a level from which one release of the spring brake actuators is possible.

2.4.3. In any case, during re-charging of the braking system from zero pressure, the spring brakes shall remain fully applied, irrespective of the position of the control device, until the pressure in the service braking system is sufficient to ensure at least the prescribed secondary braking performance of the laden vehicle, using the service braking system control device.

2.4.4. Once applied, the spring brakes shall not release unless there is sufficient pressure in the service braking system to at least provide the prescribed residual braking performance of the laden vehicle as specified in point 3.1.4. of Annex II by application of the service braking control device.

2.5. On tractors, the system shall be so designed that it is possible to apply and release the brakes at least three times if the initial pressure in the spring compression chamber is equal to the maximum design pressure. In the case of towed vehicles with compressed-air

braking systems, it shall be possible to release the brakes at least three times after the towed vehicle has been uncoupled, the pressure in the supply line being 750 kPa before the uncoupling. However, prior to the check the emergency brake shall be released. These conditions shall be satisfied when the brakes are adjusted as closely as possible. In addition, it shall be possible to apply and release the parking braking system as specified in point 2.2.2.10. of Annex I when the trailer is coupled to the tractor.

2.6. In the case of tractors, the pressure in the spring compression chamber at which the springs begin to actuate the brakes, the latter being adjusted as closely as possible, shall not be greater than 80 % of the minimum level of the normal available pressure.

2.7. In the case of towed vehicles with compressed-air braking systems, the pressure in the spring compression chamber at which the springs begin to actuate the brakes shall not be greater than that obtained after four full-stroke actuations of the service braking system in accordance with point 1.3. of Part A of Annex IV. The initial pressure is fixed at 700 kPa.

2.8. In case of towed vehicles with hydraulic braking systems not using stored energy to pressurize the spring compression chamber, the pressure at which the springs begin to actuate the brakes shall not be greater than 1,200 kPa.

2.9. In case of towed vehicles with hydraulic braking systems using stored energy to pressurize the spring compression chamber, the pressure in the spring compression chamber at which the springs begin to actuate the brakes shall not be greater than that obtained after four full-stroke actuations of the service braking system in accordance with point 1.3. of Part C of Annex IV. The initial pressure is fixed at 12,000 kPa. In addition, the pressure in the supplementary line at which the springs begin to actuate the brakes shall not be greater than 1,200 kPa.

2.10. When the pressure in the line feeding energy to the spring compression chamber - excluding lines of an auxiliary release device using a fluid under pressure - falls to the level at which the brake parts begin to move, an optical or audible warning device shall be actuated. Provided this requirement is met, the warning device may comprise the warning signal specified in point 2.2.1.29.1.1. of Annex I. This provision does not apply to towed vehicles.

2.11. If a tractor authorized to tow a vehicle of category R and S with a continuous or semi-continuous braking is fitted with a spring braking system, automatic application of the said system shall cause the application of the towed vehicle’s brakes.

2.12. Towed vehicles which utilise the compressed-air service braking system energy reserves to fulfil the requirements for the automatic brake as laid down in point 3.2.3. of Annex II shall also fulfil one of the following requirements when the towed vehicle is uncoupled from the tractor and the towed vehicle park brake control device is in the released position (spring brakes not applied):

2.12.1. when the energy reserves of the service braking system reduce to a pressure no lower than 280 kPa the pressure in the spring brake compression chamber shall reduce to 0 kPa to fully apply the spring brakes. This requirement shall be verified with a constant service braking system energy reserve pressure of 280 kPa;

2.12.2. a reduction in the pressure within the service braking system energy reserve results in a corresponding reduction in the pressure in the spring compression chamber.

3. Auxiliary Release System

3.1. A spring braking system shall be so designed that, in the event of a failure in that system, it is still possible to release the brakes. This may be achieved by the use of an auxiliary release device (pneumatic, hydraulic, mechanical, etc.).

Auxiliary release devices using an energy reserve for releasing shall draw their energy from an energy reserve which is independent from the energy reserve normally used for the spring braking system. The pneumatic or hydraulic fluid in such an auxiliary release device may act on the same piston surface in the spring compression chamber which is used for the normal spring braking system under the condition that the auxiliary release device uses a separate line. The junction of this line with the normal line connecting the control device with the spring brake actuators shall be at each spring brake actuator immediately before the port to the spring compression chamber, if not integrated in the body of the actuator. This junction shall include a device which prevents an influence of one line on the other. The requirements laid down in point 2.2.1.5. of Annex I also apply to this device.

3.1.1. For the purposes of the requirement laid down in point 3.1., components of the braking system transmission shall not be regarded as subject to failure if they are not regarded as liable to breakage in accordance with point 2.2.1.2.7. of Annex I, provided that they are made of metal or of a material having similar characteristics and do not undergo significant distortion in normal braking.

3.2. If the operation of the auxiliary device referred to in point 3.1. requires the use of a tool or spanner, that tool or spanner shall be kept on the vehicle.

3.3. Where an auxiliary release system utilizes stored energy to release the spring brakes the following additional requirements shall apply:

3.3.1. Where the control device of the auxiliary spring brake release system is the same as that used for the secondary or parking braking system, the requirements laid down in point 2.4. shall apply in all cases.

3.3.2. Where the control device for the auxiliary spring brake release system is separate to the secondary or parking braking system control device, the requirements laid down in point 2.3. shall apply to both control systems. However, the requirements laid down in point 2.4.4. shall not apply to the auxiliary spring brake release system. In addition, the auxiliary release control device shall be located so that it is protected against application by the driver from the normal driving position.

3.4. If compressed air is used in the auxiliary release system, the system should be activated by a separate control device, not connected to the spring brake control device.

ANNEX VI
Requirements applying to parking braking systems equipped with a mechanical brake-cylinder locking device

1. Definitions

For the purposes of this Annex:

1.1. ‘mechanical brake-cylinder locking device’ means a device which ensures braking operation of the parking braking system by mechanically locking the brake piston rod. Mechanical locking is effected by exhausting the compressed fluid held in the locking chamber; it is so designed that unlocking can be effected by restoring pressure in the locking chamber.

2. Requirements

2.1. The mechanical brake-cylinder locking device shall be designed in such a way that it can be released when the locking chamber is again subjected to pressure.

2.2. When the pressure in the locking chamber approaches the level corresponding to mechanical brake-cylinder locking device, an optical or audible warning system shall be actuated. This provision does not apply to towed vehicles. In the case of towed vehicles the pressure corresponding to mechanical brake-cylinder locking device shall not exceed 4 kPa. It shall be possible to achieve parking braking system performance after any single failure of the towed vehicle service braking system. In addition, it shall be possible to release the brakes at least three times after the towed vehicle has been uncoupled, the pressure in the supply line being 650 kPa before the uncoupling. These conditions shall be satisfied when the brakes are adjusted as closely as possible. It shall also be possible to apply and release the parking braking system as specified in point 2.2.2.10. of Annex I when the towed vehicle is coupled to the tractor.

2.3. In the case of brake actuators fitted with a mechanical brake-cylinder locking device, the brake actuator shall be capable of being actuated by either of two energy reserves.

2.4. The locked brake cylinder may only be released if it is certain that the brake can be operated again after such release.

2.5. In the event of a failure of the source of energy supplying the locking chamber, an auxiliary unlocking device (mechanical or pneumatic, for instance) using, for example, the air in one of the tyres of the vehicle, shall be provided.

2.6. The control device shall be such that, when actuated, it performs the following operations in sequence: it applies the brakes so as to provide the degree of efficiency required for parking braking, locks the brakes in that position and then cancels out the brake-application force.

ANNEX VII
Alternative test requirements for vehicles for which Type-I, Type-II or Type-III tests are not mandatory

1. Definitions

For the purposes of this Annex:

1.1. ‘subject towed vehicle’ means a towed vehicle representative of the towed vehicle type for which type-approval is sought;

1.2. ‘identical’ means systems, components, separate technical units and parts having identical geometric and mechanical characteristics and the materials used for the components of the vehicles;

1.3. ‘reference axle’ means an axle for which there is a test report;

1.4. ‘reference brake’ means a brake for which there is a test report.

2. General requirements

Type-I and/or Type-II or Type-III tests, laid out in Annex II, need not be performed on a vehicle and its systems, components and separate technical units submitted for approval in the following cases:

2.1. The vehicle concerned is a tractor or a towed vehicle which, as regards tyres, braking energy absorbed per axle, and mode of tyre fitting and brake assembly, is identical with respect to braking with a tractor or a towed vehicle which:

2.1.1. Has passed the Type-I and/or Type-II or Type-III test; and

2.1.2. Has been approved, with regard to the braking energy absorbed, for mass per axle not lower than that of the vehicle concerned.

2.2. The vehicle concerned is a tractor or a towed vehicle whose axle or axles are, as regards tyres, braking energy absorbed per axle, and mode of tyre fitting and brake assembly, identical with respect to braking with an axle or axles which have individually passed the Type-I and/or Type-II or Type-III test for masses per axle not lower than that of the vehicle concerned, provided that the braking energy absorbed per axle does not exceed the energy absorbed per axle in the reference test or tests carried out on the individual axle.

2.3. The vehicle concerned is a tractor equipped with an endurance braking system, other than the engine brake, identical with an endurance braking system already tested under the following conditions:

2.3.1. The endurance braking system shall, by itself, in a test carried out on a gradient of at least 6 per cent (Type-II test), have stabilized a vehicle whose maximum mass at the time of the test was not less than the maximum mass of the vehicle submitted for approval;

2.3.2. It shall be verified in the above test that the rotational speed of the rotating parts of the endurance braking system, when the vehicle submitted for approval reaches a road speed of 30 km/h, is such that the retarding torque is not less than that corresponding to the test referred to in point 2.3.1.

2.4. The vehicle concerned is a towed vehicle equipped with air operated S-cam or disc brakes which satisfy the verification requirements of Appendix 1 relative to the control of characteristics compared to the characteristics given in a report of a reference axle test as shown in the test report. Other brake designs from air operated S-cam or disc brakes may be approved upon presentation of equivalent information.

3. Specific requirements for towed vehicles

In the case of towed vehicles, these requirements are deemed to be fulfilled, with respect to point 2.1. and 2.2., if the identifiers referred to in point 3.7. of Appendix 1 for the axle or brake of the subject towed vehicle are contained in a report for a reference axle/brake.

4. Type-approval certificate

Where the foregoing requirements are applied, the type approval certificate shall include the following particulars:

4.1. In the case under point 2.1., the approval number of the vehicle subjected to the Type-I and/or Type-II or Type-III test of reference shall be entered.

4.2. In the case under point 2.2. , Table I in the template set out in Article 25(2) of Regulation (EU) No 167/2013 shall be completed.

4.3. In the case under point 2.3., Table II in the template set out in Article 25(2) of Regulation (EU) No 167/2013 shall be completed.

4.4. If point 2.4. is applicable, Table III in the template set out in Article 25(2) of Regulation (EU) No 167/2013 shall be completed.

5. Documentation

Where the applicant for a type approval in a Member State refers to a type approval granted in another Member State, the documentation shall be submitted by the applicant relating to that approval.

Appendix 1

Alternative procedures for Type-I or Type-III tests for towed vehicle brakes

1. General

1.1. In accordance with point 2.4., the Type-I or Type-III test may be waived at the time of type approval of the vehicle provided that the braking system components comply with the requirements of this appendix and that the resulting predicted braking performance meets the requirements of this Regulation for the appropriate vehicle category.

1.2. Tests carried out in accordance with the methods detailed in this appendix shall be deemed to meet the above requirements.

1.3. Tests carried out in accordance with point 3.6. and the results in the test report shall be acceptable as a means of proving compliance with the requirements laid down in point 2.2.2.8.1. of Annex I.

1.4. The adjustment of the brake(s) shall, prior to the Type-III test below, be set according to the following procedures as appropriate:

1.4.1. In the case of air operated towed vehicle brake(s), the adjustment of the brakes shall be such as to enable the automatic brake adjustment device to function. For this purpose the actuator stroke shall be adjusted to:

$s_0 > 1.1 \cdot s_{re\text{-}adjust}$ (the upper limit shall not exceed a value recommended by the manufacturer),

Where:

$s_{re\text{-}adjust}$ is the re-adjustment stroke according to the specification of the manufacturer of the automatic brake adjustment device, i.e. the stroke, where it starts to re-adjust the running clearance of the brake with an actuator pressure of 100 kPa.

Where, by agreement with the Technical Service, it is impractical to measure the actuator stroke, the initial setting shall be agreed with the Technical Service.

From the above condition the brake shall be operated with an actuator pressure of 200 kPa, 50 times in succession. This shall be followed by a single brake application with an actuator pressure of ≥ 650 kPa.

1.4.2. In the case of hydraulically operated towed vehicle disc brakes no setting requirements are deemed necessary.

1.4.3. In the case of hydraulically operated towed vehicle drum brakes the adjustment of the brakes shall be as specified by the manufacturer.

1.5. In the case of towed vehicles equipped with automatic brake adjustment devices the adjustment of the brakes shall, prior to the Type-I test below, be set according to the procedure as laid down in point 1.4.

2. Symbols used in this Annex are explained in the following table:

2.1. Symbols

P = part of the vehicle mass borne by the axle under static conditions

F = normal reaction of road surface on the axle under static conditions = $P \cdot g$

F_R = total normal static reaction of road surface on all wheels of towed vehicle

F_e = test axle load

P_e = F_e / g

g = acceleration due to gravity: g = 9.81 m/s^2

C = brake input torque

C_O = brake input threshold torque

$C_{0,dec}$ = declared brake input threshold torque

C_{max} = maximum brake input torque

R = dynamic tyre rolling radius as specified by the tyre manufacturer. As an alternative, if such information is not available, the value calculated by the formula: "ETRTO overall diameter /2" may be used;

T = brake force at tyre/road interface

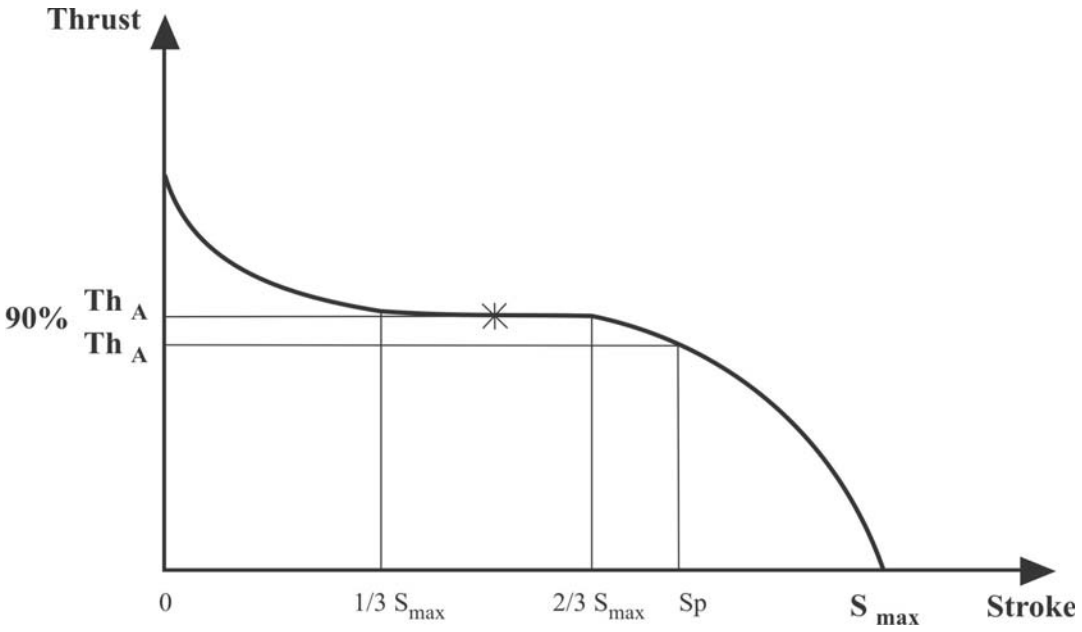
T_R = total brake force at tyre/road interface of the towed vehicle

M = brake torque = $T \cdot R$

z = braking rate = T/F or $M/(R \cdot F)$

s = actuator stroke (working stroke plus free stroke)

s_p = the effective stroke (the stroke at which the output thrust is 90% of the average thrust ThA);



Th_A = average thrust (the average thrust is determined by integrating the values between 1/3 and 2/3 of the total stroke S_{max})

l = lever length

r = internal radius of brake drums or effective radius of brake discs

p = brake actuation pressure

Note: Symbols with the suffix "e" relate to the parameters associated with the reference brake test and may be added to other symbols as appropriate.

3. Test methods

3.1. Track tests

3.1.1. The brake performance tests should preferably be carried out on a single axle only.

3.1.2. The results of tests on a combination of axles may be used in accordance with point 2.1. provided that each axle contributes equal braking energy input during the drag and hot brake tests.

3.1.2.1. This is ensured if the following are identical for each axle: braking geometry, lining, wheel mounting, tyres, actuation and pressure distribution in the actuators.

3.1.2.2. The documented result for a combination of axles will be the average for the number of axles, as though a single axle had been used.

3.1.3. The axle(s) should preferably be loaded with the maximum static axle load, though this is not essential provided that due allowance is made during the tests for the difference in rolling resistance caused by a different load on the test axle(s).

3.1.4. Allowance shall be made for the effect of the increased rolling resistance resulting from a combination of vehicles being used to carry out the tests.

3.1.5. The initial speed of the test shall be that prescribed. The final speed shall be calculated by the following formula:

$$v_2 = v_1 \sqrt{\frac{P_o + P_1}{P_o + P_1 + P_2}}$$

However, in the case of Type-III test, the speed correction formula according to point 2.5.4.2. of Annex II applies

Where:

v_1 = initial speed (km/h),

v_2 = final speed (km/h),

P_o = mass of the tractor (kg) under test conditions,

P_1 = part of the mass of the towed vehicle borne by the unbraked axle(s) (kg),

P_2 = part of the mass of the towed vehicle borne by the braked axle(s) (kg).

3.2. Inertia dynamometer tests

3.2.1. The test machine shall have a rotary inertia simulating that part of the linear inertia of the vehicle mass acting upon one wheel, necessary for the cold performance and hot performance tests, and capable of being operated at constant speed for the purpose of the test described in points 3.5.2. and 3.5.3.

3.2.2. The test shall be carried out with a complete wheel, including the tyre, mounted on the moving part of the brake, as it would be on the vehicle. The inertia mass may be connected to the brake either directly or via the tyres and wheels.

3.2.2.1. By way of derogation from point 3.2.2., the test may be also carried out without a tyre under the condition that no cooling is permitted. However, in order to suck away toxic or harmful gases from the test chamber a small air circulation is permitted.

3.2.3. Under the conditions specified in point 3.2.2., air cooling at a velocity and air flow direction simulating actual conditions may be used during the heating runs, the speed of the air flow being

$v_{air} = 0.33\ v$

Where:

v = vehicle test speed at initiation of braking.

The temperature of the cooling air shall be the ambient temperature.

3.2.4. Where the tyre rolling resistance is not automatically compensated for in the test, the torque applied to the brake shall be modified by subtracting a torque equivalent to a rolling resistance coefficient of 0.02 (in the case of vehicles of categories Ra and Sa) and 0.01 (in the case of vehicles of categories Rb and Sb) respectively.

Alternatively, the worst case rolling resistance coefficient of 0.01 may be used in order to cover all vehicle categories which may be subjected to the Type-I test, as determined in the test report.

3.3. Rolling road dynamometer tests

3.3.1. The axle should preferably be loaded with the maximum static axle mass though this is not essential provided that due allowance is made during the tests for the difference in rolling resistance caused by a different mass on the test axle.

3.3.2. Air cooling at a velocity and air flow direction simulating actual conditions may be used during the heating runs, the speed of the air flow being

$v_{air} = 0.33\ v$

Where:

v = vehicle test speed at initiation of braking.

The temperature of the cooling air shall be the ambient temperature.

3.3.3. The braking time shall be 1 second after a maximum build-up time of 0.6 second.

3.4. Test conditions (General)

3.4.1. The test brake(s) shall be instrumented so that the following measurements can be taken:

3.4.1.1. A continuous recording to enable the brake torque or force at the periphery of the tyre to be determined;

3.4.1.2. A continuous recording of air pressure in the brake actuator;

3.4.1.3. Vehicle speed during the test;

3.4.1.4. Initial temperature on the outside of the brake drum or brake disc;

3.4.1.5. Brake actuator stroke used during Type-0 and Type-I or Type-III tests.

3.5. Test procedures

3.5.1. Supplementary cold performance test

The preparation of the brake shall be in accordance with point 3.5.1.1.

3.5.1.1. Bedding in (burnishing) procedure

3.5.1.1.1. In the case of drum brakes the tests shall start with new brake linings and new drum(s), the brake linings shall be machined to achieve the best possible initial contact between the linings and drum(s).

3.5.1.1.2. In the case of disc brakes the tests shall start with new brake pads and new disc(s), machining of the pad material shall be at the discretion of the brake manufacturer.

3.5.1.1.3. Make 20 brake applications from an initial speed of 60 km/h with an input to the brake theoretically equal to 0.3 TR/Test Mass. The initial temperature at the lining/drum or pad/disc interface shall not exceed 100 °C before each brake application.

3.5.1.1.4. Carry out 30 brake applications from 60 km/h to 30 km/h with an input to the brake equal to 0.3 TR/Test Mass and with a time interval between applications of 60 s. If the track test method or the rolling road test methods are to be utilized, energy inputs equivalent to those specified shall be used. The initial temperature at the lining/drum or pad/disc interface on the first brake application shall not exceed 100 °C.

3.5.1.1.5. On completion of the 30 brake applications specified in point 3.5.1.1.4. and after an interval of 120 s carry out 5 brake applications from 60 km/h to 30 km/h with an input to the brake equal to 0.3 TR/Test Mass and with an interval of 120 s between applications[4].

3.5.1.1.6. Make 20 brake applications from an initial speed of 60 km/h with an input to the brake equal to 0.3 TR/Test Mass. The initial temperature at the lining/drum or pad/disc interface shall not exceed 150 °C before each brake application.

3.5.1.1.7. Carry out a performance check as follows:

3.5.1.1.7.1. Calculate the input torque to produce theoretical performance values equivalent to 0.2, 0.35 and 0.5 + 0.05 TR/Test Mass.

3.5.1.1.7.2. Once the input torque value has been determined for each braking rate, this value shall remain constant throughout each and subsequent brake applications (e.g. constant pressure).

3.5.1.1.7.3. Make a brake application with each of the input torques determined in point 3.5.1.1.7.1. from an initial speed of 60 km/h. The initial temperature at the lining/drum or pad/disc interfaces shall not exceed 100 °C before each application.

3.5.1.1.8. Repeat the procedures laid down in point 3.5.1.1.6. and 3.5.1.1.7.3., where point 3.5.1.1.6. is optional, until the performance of five consecutive non monotonic measurements at the 0.5 TR/(Test Mass) constant input value has stabilized within a tolerance of minus 10 per cent of the maximum value.

3.5.1.2. It is also permissible to carry out the two fade tests, Type-I and Type- III, one after the other.

3.5.1.3. This test is carried out at an initial speed equivalent to 40 km/h in the case of Type-I test and 60 km/h in the case of Type-III test in order to evaluate the hot braking performance at the end of Type-I and Type-III tests. The Type-I and/or Type-III fade test has/have to be done immediately after this cold performance test.

3.5.1.4. Three brake applications are made at the same pressure (p) and at an initial speed equivalent to 30 km/h and 40 km/h respectively (in the case of Type-I test, as determined in the test report) or 60 km/h (in the case of Type-III test), with an approximately equal initial brake temperature not exceeding 100 °C, measured at the outside surface of the drums or discs. The applications shall be at the brake actuator pressure required to give a brake torque or force equivalent to a braking rate (z) of at least 50 per cent. The brake actuator pressure shall not exceed 650 kPa (pneumatic) or 11,500 kPa (hydraulic), and the brake input torque (C) shall not exceed the maximum permissible brake input torque (C_{max}). The average of the three results shall be taken as the cold performance.

3.5.2. Fade test (Type-I test)

3.5.2.1. This test is carried out at a speed equivalent to 40 km/h with an initial brake temperature not exceeding 100 °C, measured at the outside surface of the drum or brake disc.

3.5.2.2. A braking rate is maintained at 7 per cent, including the rolling resistance (see point 3.2.4.).

3.5.2.3. The test is made during 2 minutes and 33 seconds or during 1.7 km at a vehicle speed of 40 km/h. In case of towed vehicles with $v_{max} \leq 30$ km/h or if the test velocity cannot be achieved, then the duration of the test can be lengthened according to point 2.3.2.2. of Annex II.

3.5.2.4. Not later than 60 seconds after the end of the Type-I test, a hot performance test is carried out in accordance with point 2.3.3. of Annex II at an initial speed equivalent to 40 km/h. The brake actuator pressure shall be that used during the Type-0 test.

3.5.3. Fade test (Type-III test)

3.5.3.1. Test methods for repeated braking

3.5.3.1.1. Track tests (see Annex II, point 2.5.)

3.5.3.1.2. Inertia dynamometer test

For the bench test described in point 3.2., the conditions may be the same as for the road test described in point 2.5.4. of Annex II with:

$$v_2 = \frac{v_1}{2}$$

3.5.3.1.3. Rolling road dynamometer test

For the bench test described in point 3.3, the conditions shall be as follows:

Number of brake applications	20
Duration of braking cycle (braking time 25 s and recovery time 35 s)	60 s
Test speed	30 km/h
Braking rate	0.06
Rolling resistance	0.01

3.5.3.2. Not later than 60 seconds after the end of the Type-III test a hot performance test is carried out in accordance with point 2.5.5. of Annex II. The brake actuator pressure shall be that used during the Type-0 test.

3.6. Performance requirements for automatic brake adjustment devices

3.6.1. The following requirements shall apply to an automatic brake adjustment device which is installed on a brake, the performance of which is being verified according to the provisions of this appendix.

On completion of the tests defined in points 3.5.2.4. (Type-I test) or 3.5.3.2. (Type-III test), the requirements laid down in point 3.6.3. shall be verified.

3.6.2. The following requirements shall apply to an alternative automatic brake adjustment device installed on a brake for which a test report already exists.

3.6.2.1. Brake performance

Following heating of the brake(s) carried out in accordance with the procedures described in points 3.5.2. (Type-I test) or 3.5.3. (Type-III test), as appropriate, one of the following provisions shall apply:

(a) the hot performance of the service braking system shall be ≥ 80 per cent of the prescribed Type-0 performance; or

(b) the brake shall be applied with a brake actuator pressure as used during the Type-0 test; at this pressure the total actuator stroke (s_A) shall be measured and shall be $\leq 0.9\ s_p$ value of the brake chamber.

s_p = the effective stroke means the stroke at which the output thrust is 90% of the average thrust (Th_A) - see point 2.

3.6.2.2. On completion of the tests specified in point 3.6.2.1., the requirements laid down in point 3.6.3. shall be verified.

3.6.3. Free running test

After completing the tests specified in points 3.6.1. or 3.6.2., as applicable, the brake(s) shall be allowed to cool to a temperature representative of a cold brake (i.e. ≤ 100 °C) and it should be verified that the towed vehicle/wheel(s) is capable of free running by fulfilling one of the following conditions:

3.6.3.1. Wheels are running freely (i.e. wheels can be rotated by hand);

3.6.3.2. It is ascertained that at a constant speed equivalent to v = 60 km/h with the brake(s) released the asymptotic temperature shall not exceed a drum/disc temperature increase of 80 °C, then this residual brake moment is regarded as acceptable.

3.7. Identification

3.7.1. The axle shall carry at a visible position the marking in accordance with the requirements laid down on the basis of Article 17 (2) (k) and (5) of Regulation (EU) 167/2013, so that the following data are uniquely identified, as mentioned in the test report:

3.7.1.1. Axle identifier;

3.7.1.2. Brake identifier;

3.7.1.3. F_e identifier;

3.7.1.4. Base part of test report number;

3.7.1.5. The identifiers specified in the test report.

3.7.2. A non-integrated automatic brake adjustment device shall carry at a visible position at least the marking in accordance with the requirements laid down on the basis of Article 17 (2) (k) and (5) of Regulation (EU) 167/2013 so that the following data are uniquely identified, as mentioned in the test report:

3.7.2.1. Type;

3.7.2.2. Version.

3.7.3. The make and type of each brake lining or pad shall be visible when the lining or pad is mounted on the brake shoe or back plate in a legible and indelible manner.

3.8. Test criteria

In the case that a new test report, or a test report extension, is required for a modified axle or brake within the limits specified in the information document the following criteria are used to determine the necessity for further testing taking into account worst case configurations agreed with the Technical Service.

Abbreviations used in the subsequent table:	
CT (complete test)	Test: 3.5.1.: Supplementary cold performance test 3.5.2.: Fade test (Type-I test)* 3.5.3.: Fade test (Type-III test)*
FT (fade test)	Test: 3.5.1.: Supplementary cold performance test 3.5.2.: Fade test (Type-I test)* 3.5.3.: Fade test (Type-III test)*

* If applicable

Differences according to the information document	*Test criteria*
(a) Increase in maximum declared brake input torque C_{max}	Change allowed without additional testing
(b) Deviation of declared brake disc and brake drum mass m_{dec}: ± 20 per cent	CT: The lightest variant shall be tested; if the nominal test mass for a new variant deviates less than 5 per cent from a previously tested variant with a higher nominal value then the test of the lighter version may be dispensed with. The actual test mass of the test specimen may vary ±5 per cent from the nominal test mass.
(c) Method of attachment of the lining / pad on the brake shoe / back plate	The worst case specified by the manufacturer and agreed by the Technical Services conducting the test
(d) In the case of disc brakes, increase of maximum stroke capability of the brake	Change allowed without additional testing
(e) Effective length of the cam shaft	The worst case is considered to be the lowest cam shaft torsional stiffness and shall be verified by either: (i) FT; or (ii) Change allowed without additional testing if by calculation the influence with respect to stroke and braking force can be shown. In this case the test report shall indicate the following extrapolated values: s_e, C_e, T_e, T_e/F_e.
(f) Declared threshold torque $C_{0,dec}$	It shall be checked that the brake performance remains within the corridors of Diagram 1

Differences according to the information document	*Test criteria*
(g) ±5 mm from the declared external diameter of the disc	The worst case test is considered the smallest diameter The actual external diameter of the test specimen may vary ±1 mm from the nominal external diameter specified by the axle manufacturer.
(h) Type of cooling of the disc (ventilated/non-ventilated)	Each type shall be tested
(i) Hub (with or without integrated hub)	Each type shall be tested
(j) Disc with integrated drum – with or without parking braking system function	Testing is not required for this feature
(k) Geometric relationship between disc friction surfaces and disc mounting	Testing is not required for this feature
(l) Brake lining type	Each type of brake lining
(m) Material variations (excluding changes in base material), as in the information document for which the manufacturer confirms that such a material variation does not change the performance with respect to the required tests	Test not required for this condition
(n) Back plate and shoes	Worst case test conditions*: Back plate: minimum thickness Shoe: lightest brake shoe

* No test is required if the manufacturer can demonstrate that a change does not affect the stiffness.

3.8.1. If an automatic brake adjustment device deviates from a tested one with reference to the identifiers of the test report, an additional test according to point 3.6.2. is necessary.

3.9. Test results

3.9.1. The result of tests carried out in accordance with points 3.5. and 3.6.1. shall be reported on the test results sheet.

3.9.2. In the case of a brake installed with an alternative brake adjustment device the results of tests carried out in accordance with point 3.6.2. shall be reported on the test results sheet.

3.9.3. Information document

An information document, provided by the axle or vehicle manufacturer, shall be part of the test report.

The information document shall identify, if applicable, the various variants of the brake or axle equipment with respect to their essential criteria.

4. Verification

4.1. Verification of components

The brake specification of the vehicle to be type approved shall comply with the requirements laid down in points 3.7., 3.8. and 3.9.

4.2. Verification of brake energy absorbed

4.2.1. The brake forces (T) for each subject brake (for the same control line pressure p_m) necessary to produce the drag force specified for both Type-I and Type-III test conditions shall not exceed the values T_e as stated in the test report , which were taken as a basis for the test of the reference brake.

4.3. Verification of hot performance

4.3.1. The brake force (T) for each subject brake for a specified pressure (p) in the actuators and for a control line pressure (p_m) used during the Type-0 test of the subject towed vehicle is determined as follows:

4.3.1.1. The predicted actuator stroke (s) of the subject brake is calculated as follows:

$$s = l \cdot \frac{s_e}{l_e}$$

This value shall not exceed s_p.

4.3.1.2. The average thrust output (Th_A) of the actuator fitted to the subject brake at the pressure specified in point 4.3.1. is measured.

4.3.1.3. The brake input torque (C) is then calculated as follows:

$C = Th_A \cdot l$

C shall not exceed C_{max}.

4.3.1.4. The predicted brake performance for the subject brake is given by:

$$T = \left(T_e - 0.01 \cdot F_e\right) \frac{C - C_o}{C_e - C_{oe}} \cdot \frac{R_e}{R} + 0.01 \cdot F$$

R shall not be less than $0.8\ R_e$.

4.3.2. The predicted brake performance for the subject towed vehicle is given by:

$$\frac{T_R}{F_R} = \frac{\Sigma T}{\Sigma F}$$

4.3.3. The hot performances following the Type-I or Type-III tests shall be determined in accordance with points 4.3.1.1. to 4.3.1.4. The resulting predictions given by point 4.3.2. shall satisfy the requirements of this Regulation for the subject towed vehicle. The value used for the figure recorded in the Type-0 test as prescribed in point 2.3.3. or 2.5.5. of Annex II shall be the figure recorded in the Type-0 test of the subject towed vehicle.

DIAGRAM 1