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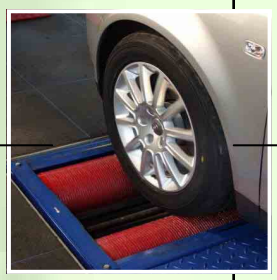
COMITÉ INTERNATIONAL DE L'INSPECTION TECHNIQUE AUTOMOBILE
INTERNATIONAL MOTOR VEHICLE INSPECTION COMMITTEE
INTERNATIONALE VEREINIGUNG FÜR DIE TECHNISCHE PRÜFUNG VON KRAFTFAHRZEUGEN



Recommendation no. 8
Brake testing of heavy vehicles and cars

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INTERNATIONAL MOTOR VEHICLE INSPECTION COMMITTEE

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RECOMMENDATION N° 8

BRAKE TESTING OF HEAVY VEHICLES AND CARS

INTRODUCTION

CITA Recommendation 1 lists the items that should be inspected during periodic inspection, the method of inspection and the principle reasons for failure. Section 1 covers braking systems. The purpose of this CITA Recommendation is to specify in more detail recommended test methods and equipment for assessing the ***performance*** of vehicle braking systems.

A general assumption of periodic inspection is that new vehicles comply with legal requirements. The principal aim of periodic inspection is to test whether a vehicle has been properly maintained and is still roadworthy.

This CITA Recommendation is based on the requirements regarding braking systems in European Union council directive n° 96/96/EC[1] on roadworthiness tests for motor vehicles and their trailers, as amended[2]. It has been developed by CITA Working Group 5 and takes account of the draft ISO standard[3] for roller brake testers and the 07 supplement to UN/ECE Regulation 13.09 concerning reference brake forces for periodic technical inspections.

Vehicles in traffic must fulfil certain requirements which are stipulated by legal authorities. This CITA Recommendation does not include these criteria.

[1] EC Council directive 96/96/EC of 20 December 1996, OJ L46 of 17 February 1997
[2] Commission directives 1999/52/EC of 26 May 1999 , OJ L142, 5 June 1999; 2001/9/EC of 12 February 2001, OJ L48 of 17 February 2001; 2001/11/EC of 12 February 2001, OJ L48 of 17 February 2001; 2003/27/EC of 3 April 2003, OJ L90 of 8 April 2003.
[3] DIS 21069 part 1

1. PERIODIC INSPECTION OF LOAD SENSING VALVE
(Point 1.1.17. of Annex 2 to dir n° 96/96/EC)

Note 1: **Only** applicable for vehicles with LSVs with internal simulation or LSVs fitted with an external 'T bar' simulation valve.

Note 2: Vehicles with an electronic brake system (EBS), where the braking force control is regulated electronically, cannot be tested as described below.

1.1. PNEUMATICALLY OPERATED LSV

1.1.1 As the measuring method consists of checking the actual performance against the data on the LSV plate, an LSV plate with at least the following information must be present;
- The input reference pressure.
- The air suspension bellows pressure and the corresponding output pressure of the LSV for at least 2 values, e.g. empty and the fully laden axle load.

1.1.2 The method of test is set out in **ANNEX A**, section A.1.

1.2. MECHANICALLY OPERATED LSV

1.2.1 As the measuring method consists of checking the actual performance against the data on the LSV plate, an LSV plate with at least the following information must be present:
- The input reference pressure.
- The spring movement fs in mm. (deflection of the springs in loaded state; information from the axle constructor)
- The lever length L in mm.
- The axle load and the corresponding output pressure of the LSV for at least 2 values, e.g. empty and the fully laden axle load.

1.2.2 The method of test is set out in **ANNEX A**, section A.2.

2. PERIODIC INSPECTION OF AUTOMATIC SLACK ADJUSTERS
(Point 1.1.18. of Annex 2 to dir n° 96/96 EEC)

2.2. It is not recommended that the function of automatic slack adjusters is directly tested during periodic inspection. Instead, they should be checked visually for correct installation (correct angles) and adjustment (amount of slack). In addition checks should be made for damage, excessive wear or signs of seizure or other defects and that other related components are not missing, disconnected or insecure.

2.3. If the checks reveal any defect that would affect the correct functioning of an automatic slack adjuster, the vehicle should be failed.

3. PERIODIC INSPECTION OF RETARDERS
(Point 1.1.19. of Annex 2 to dir n° 96/96 EEC)

3.1. Apart from a check that the retarder control is capable of gradual variation, it is not recommended that the function of retarders is directly tested at periodic inspection.

3.2. However, if there are indications of malfunction and functional testing is possible, the following method can be applied;

3.2.1 Decelerate the vehicle on a level road from at least 30 km/h by means of the retarder alone. Evaluate the deceleration either by means of a decelerometer or by calculating deceleration (by measuring the time it takes to reduce the speed by a known amount).

3.2.2 If the performance is significantly lower than that achieved by the same kind of retarder in good condition, the vehicle should be failed.

3.3. The normal procedure for checking retarders at periodic inspection is a visual check for any problems that could affect its correct functioning and, for systems with on-board diagnostics, that no malfunction signal is activated.

3.3.1 Check visually for mechanical damage to the retarder, for leaks in hydraulic retarders and for damage to the electrical system in electromagnetic retarders.

3.3.2 If there is a malfunction signal or any damage that reduces the retarder's ability to function correctly the vehicle should be failed.

4. PERIODIC INSPECTION OF VEHICLES WITH ABS / EBS BRAKES

4.1. The following method should be regarded as the normal method for periodic inspection. It is limited to checks which can be carried out easily and without any special vehicle make or model specific equipment.

4.2.1 Status of ABS / EBS warning signal

Check that the warning signal goes on when the ignition is switched on (this is to check that the warning signal itself is functioning). Check that the warning signal goes out in the appropriate manner. These vary from system to system. Usually the warning signal goes out after a specified time lapse or when the vehicle exceeds a certain "speed threshold". The characteristics of all the vehicle types likely to be tested should be known. If the warning device stays on, the vehicle should be failed.

4.2.2 Electrical wiring

Check visually for faults, such as damaged wires or connectors that could affect the correct functioning. If there is any damage that could indicate broken electrical connections, the vehicle should be failed.

4.2.3 Hydraulic/pneumatic parts

Using normal methods, check hydraulic and pneumatic systems for leaks. Vehicles not meeting normal criteria for leakage rates should be failed.

4.2.4 Mechanical parts

Check visually all accessible mechanical parts. If there is any mechanical defect which is likely to affect the correct functioning of the system, the vehicle should be failed.

5. PERIODIC INSPECTION OF BRAKE EFFICIENCY OF HEAVY VEHICLES (Point 1.2.2. of Annex 2 to 96/96 EEC)

5.1. Periodic inspection generally has to be carried out in the condition vehicles are presented by their owners. Most heavy vehicles are presented unloaded or only partially loaded. This means that maximum braking forces can be difficult to establish on a roller brake tester, since wheels tend to lock before the maximum service line air pressure is reached.

5.2. There are two basic approaches to overcome this problem. One is to apply an artificial load on the vehicle or the axle. The other is to extrapolate from air pressure and brake force values registered during roller brake testing in condition as presented. The two approaches can also be used together.

5.3. The following method uses 'extrapolation'. As well as specifying the test method, the properties of the equipment that is required (air pressure gauges and connectors) are also specified. The method is applicable to heavy vehicles with fully pneumatic braking systems, or mainly pneumatic braking systems where only part of the transmission is hydraulic and this part does not contain any reduction valves.

5.4. The method takes as a basic presumption that the brake forces increase in direct proportion to the service line air pressure.

5.5. The method proposed is as described in **ANNEX B**

6. REQUIREMENTS FOR ROLLER BRAKE TESTERS

The requirements for roller brake testers are set out in **ANNEX C**

7. REQUIREMENTS FOR PLATE BRAKE TESTERS FOR LIGHT VEHICLES (GVW ≤ 3500 kg)

The requirements for plate brake testers are set out in **ANNEX D**

8. UNITS

A list of recommended and alternative units recommended for use with brake testing equipment is set out in **ANNEX E**

ANNEX A

METHOD OF TEST FOR LOAD SENSING VALVES (LSV)

A.1. PNEUMATICALLY OPERATED LSVs

A.1.1 *Connection of manometers and pressure reducing valves*

Connect manometers and pressure reducing valves as follows –

(a) Trailer or semi-trailer:
  (i) Connect pressure reducing valve (I) and manometer (1) between the connection of the control pressure (yellow) line of the towing vehicle and the semi-trailer.
  (ii) Connect manometer (2) in front of the input of the LSV. (Depending on the location of the pressure measuring point, it can be placed on the output of the trailer brake valve or on the input of the LSV.)

(b) Towing vehicle:
  (i) Connect manometer (3) in front of the input of the LSV.
  (ii) Connect pressure reducing valve (II) and manometer (4) between the air pressure reservoir and the simulation input of the LSV.
  (iii) Connect manometer (5) on the output of the LSV.

A.1.2 *Input reference pressure*

(a) Trailer or semi-trailer:
Set the input reference pressure to the value specified on the LSV plate using pressure reducing valve (I) and manometer (1). Press the brake pedal fully down and check the value of the manometer (2). Manometer (2) shows the input pressure for the LSV and the difference between manometers (1) and (2) shows the predominance of the trailer brake valve. The input pressure is adjusted using pressure reducing valve (I) until manometer (2) reads the input reference pressure shown on the LSV plate.

(b) Towing vehicle:
The input reference pressure is not regulated by a pressure reducing valve; the brake pedal should be applied until manometer (3) indicates the reference pressure shown on the LSV plate.

A.1.3 *Suspension bellows pressure*

Different suspension bellows pressures are simulated by adjusting pressure reducing valve (II)

A.1.4 *Checking the LSV*

The progressive operation of the LSV must be tested by checking three points. It is not sufficient to check only the empty and loaded state points.

Point 1:
Pressure reducing valve (II) is set to simulate a bellows pressure of 0.00 bar.
If one of the two suspension bellows pressures remains present at the LSV, this ‘empty condition’ pressure will be the first point to check instead of 0.00 bar.
When the input reference pressure is set, the output pressure of the LSV (manometer 5) when the brake is applied must be the pressure given on the LSV plate for the empty condition, with some tolerance (e.g. +/- 0.20 bar)

Point 2:
The brakes are released and the pressure reducing valve (II) is set to simulate an increase of 0.20 bar in the bellows pressure compared to the empty state
When the input reference pressure is reset, the output pressure of the LSV (manometer 5)must show the expected increase in pressure (e.g. +0.20 bar) compared to the pressure measured at point 1 with some tolerance (e.g. +/- 0.10 bar).

Point 3:
The brakes are released and the pressure reducing valve (ii) is set to simulate a pressure which is 0.1 bar lower than the bellows pressure in loaded state. When the input reference pressure is reset, the output pressure for the LSV (manometer 5) must show the expected diminution in pressure (e.g. -0.30 bar) compared to the pressure given on the LSV plate for the full laden condition – with some tolerance (e.g. +/- 0.20 bar).

Note:
The LSVs on trailers and semi-trailers work statically; i.e. during braking, the LSV output is not adjusted in response to a change in the control signal (bellows pressure). The brakes must be released before each new suspension bellows pressure is simulated.

A.2. MECHANICALLY OPERATED LSVs

A.2.1 *Connection of manometers and pressure reducing valves*

The manometers and the pressure reducing valve should be connected in the same way as for a pneumatic LSV. However, in this case the suspension bellows pressure cannot be simulated.

A.2.2 *Input reference pressure*

The input reference pressure is set in the same way as with a pneumatically driven LSV.

A.2.3 *Checking the LSV*

Provided the vehicle is submitted empty, when the brakes are fully applied, manometer 5 should show the pressure given on the LSV plate for the empty condition, with some tolerance (e.g. +/- 0.20 bar)
A check in a simulated loaded condition can only be achieved if the mechanical lever can be adjusted manually or by the use of external load simulation. If the control lever can be moved to the position of maximum load, the accompanying output pressure can be measured and compared with the corresponding value on the LSV plate. For towed vehicles this is usually not possible, leaving only the correct lever length L to be checked against the values given on the LSV-plate.

A.2.4 *Mechanical condition*

Check that:
- All connections, constructed to move freely, are be able to do so; and
- The connection cable makes an angle of approximately 90° with a line between the connecting point for cable and lever, and the turning point for the lever (with the lever placed in the mid position, between empty and loaded).

Note:
The LSV may work statically, that is to say that a change in the lever position during braking does not affect the output pressure of the LSV.

ANNEX B

METHOD FOR THE PERIODIC INSPECTION OF BRAKE EFFICIENCY OF HEAVY VEHICLES

B.1. CONNECT AIR PRESSURE GAUGES AT SUITABLE MEASURING POINTS

Note 1: Air pressure gauges should have an adequate resolution and an accuracy in accordance with Standard ISO/DIS 21069 point A.3.3. Connectors should correspond to ISO 3584:1984 which specifies the standardized measuring points in the air pressure system of heavy vehicles. Connectors for measuring air pressure at the trailer coupling should also be available.

Note 2: The service line air pressure should be measured as close to the wheel brake cylinders as possible. There should be no reduction valve (e.g. load-sensing valve) between the measuring point and the brake cylinders of the axle to be tested. The load-sensing valve is assumed to function properly can be checked separately (see annex A for method).

The air pressure may be measured at a point further away from the wheel brake cylinders (e.g. the trailer coupling connections) if the load-sensing valve is set to open fully. Also, if there is an air pressure increasing valve before the trailer coupling, its effect must be taken into account.

B.2. MEASURE BRAKE FORCES AND CORRESPONDING AIR PRESSURE JUST BEFORE WHEELS LOCK, AXLE BY AXLE

Note: Extrapolation from as high as possible an air pressures is desirable. If the wheels lock before the air pressure has reached one third of full service line air pressure, or an alternative limit of 2 bar, extrapolation is not advisable.

B.3. CALCULATION OF MAXIMUM BRAKE FORCES

Calculate maximum brake forces for each axle according to standard ISO/DIS 21069 point 4.3.2 and 4.3.3

As a matter of preference, a computer aided roller brake tester, where both brake forces and corresponding air pressures are registered automatically, should be used.

B.4. ALTERNATIVE METHOD FOR EFFICIENCY EVALUATION

If brake forces registered on the roller brake tester are high enough to show that the braking efficiency is sufficient for the vehicle's GVW, no extrapolation is required. Measured brake forces and corresponding actuator pressures could be compared with the reference brake forces obtained from the vehicle manufacturers listed in data charts, a computerized data base system or by any other suitable means.

In order to avoid premature locking of the wheels on the roller brake tester, most vehicles will have to be tested fully or partly loaded or with some kind of artificial load. Premature locking can still occur especially in wet conditions. A "lock allowance" could then be applied in order to avoid failing vehicles with sufficient brake efficiency.

To minimize the risk for tyre damage, ISO/DIS standard 21069 point A.1.9.2 should be fulfilled.

ANNEX C

REQUIREMENTS FOR ROLLER BRAKE TESTERS

Note: Values for roller brake testers for heavy vehicles (≥ 3500 kg GVM) are un-bracketed; those for light vehicles are in brackets.

C.1. BRIEF DESCRIPTION

C.1.1 Roller brake testers are required on test lanes where heavy vehicles are inspected.

C.1.2 Roller brake testing machines consist of two pairs of rollers on which the road wheels of an axle are placed during test. The braking force produced by the road wheels is converted directly into an indication of braking effort.

C.1.3

C.2. REQUIRED FEATURES

C.2.1 *Allowable load per axle*

The maximum allowable axle weight should not be less than 13 000 kg (2500 kg).

C.2.2 *Roller diameter*

The diameter of the rollers should not be less than 200 mm (150 mm).

C.2.3 *Roller length*

The roller length should not be less than 900 mm (600 mm).

C.2.4 *Distance between the pairs of rollers*

The distance between the inside edges of the pairs of rollers should not exceed 1 m (0,9 m).

C.2.5 *Friction coefficient*

The friction coefficient should be more than 0.7 when dry and 0.5 when wet.

C.2.6 *Start and stop*

There must be manual means of starting of the rollers. In countries where automatic means of starting is permitted, this can also be provided..

If there is an automatic starting function there must be a short time lag after the vehicle axle has been placed on the roller tester before the rollers are started.

The rollers must stop automatically when the vehicle axle leaves the roller tester. A manual stop function must also be available.

The rollers must stop automatically if there is a relative difference of speed (slip) between the rollers and vehicle wheels more than 27 % ± 3 %.

C.2.7 *Accuracy*

Roller brake testers for heavy vehicles must fulfil standard ISO/DIS 21069 point A.3.

(The maximum error at any point must not exceed +/- 5 % of the actual value and +/- 3 % of the full deflection. The maximum error requirements do not indicate a stricter condition than the resolution requirements below.

When the brake force for each wheel of an axle is the same, the indication from both measuring devices must not differ by more than 2.5 % of the highest indication and maximum 1.5 % of full-scale deflection.)

C.2.8 *Measurement range and resolution*

With analogue display of measured brake forces the range per wheel shall not exceed 45 000 N (7500 N).

The resolution, whether the display is analogue or digital, shall not be less than 100 N in the range up to 5 000 N and not less than 500 N above that limit. The display shall be readily visible to the inspector when seated in the driving seat of the vehicle being inspected.

C.2.9 *Point zero*

It must be possible to set the zero point of the brake force display without a vehicle axle on the rollers. The roller resistance measured with a vehicle axle on the rollers shall be indicated as a force and not be basis for a new setting of the point zero.

C.2.10 *Calibration*

It must be possible to calibrate the roller brake tester over the full measurement range, including the zero reading, with a suitable device with or without rollers turning at idle.

C.2.11 *Testing speed*

The testing speed should be in the range 2 km/h to 6 km/h.

C.2.12 *Optional supplementary features*

If requested by the purchaser, the following features should be available for the use in conjunction with the roller brake tester.

1. Needle lock or dead-beat pointer. For digital displays a "freeze" function.

2. Provision for the connection of an additional indication unit at up to 20 m distance from the roller unit.

3. Means for changing to a lower measurement range and a smaller distance between the rollers for inspection of lighter vehicles. (Applies to roller brake testers for heavy vehicles).

4. Possibility to run one set of rollers in the opposite direction to the other set of rollers to enable testing of vehicles with multi-axle drive.

5. Automatic stop function triggered when a person is in the pit or close to the rotating rollers.

6. Automatic calculation and indication of imbalance between brake forces of wheels on the same axle.

7. Automatic calculation and indication of brake force variations in one wheel (ovality).

8. Measurement and indication of service line pressure at the trailer coupling or at a measuring point on the vehicles.

9. Recording of brake forces and corresponding service line pressure. Calculation of deceleration at gross vehicle weight (GVW) or at a weight at which the vehicle comes to inspection. Such an option requires possibilities according to point 8.

10. Graphical presentation, axle by axle and for the whole vehicle of the brake applications recorded on the roller brake tester. For the axle by axle presentation an air-pressure to brake force graph is suitable. For the whole vehicle an air-pressure to deceleration graph is recommended.

11. Electronic interfaces to PC to enable further data processing.

Note: In order to improve the repeatability of the measurements, the use of a pedal force meter is recommended.

ANNEX D

REQUIREMENTS FOR PLATE BRAKE TESTERS FOR LIGHT VEHICLES (GVW ≤ 3500 kg GVM)

D.1. BRIEF DESCRIPTION

The plate brake tester consists of two pairs of plates. Each plate consists of a chassis, which is mounted on the floor and of a moving upper plate, which rolls on linear bearings.

The moving part is connected to the chassis through a force transducer, which is connected to the central computer. The force between the braked wheel and the plate is measured. The result of the test is presented as brake force against time for each wheel on a display, or as a printout.

D.2. REQUIRED FEATURES

D.2.1 *Mechanical parts*

The plate brake tester shall consist of two pairs of plates and should be designed to test the brake system of all vehicles with a GVW not exceeding 3500 kg and to withstand a test speed of 15 km/h.

The plates shall have such dimensions and be placed in such a way that it is possible to get a sufficient braking distance for all vehicles that are tested on the plate brake tester. This demand is fulfilled if all wheels get at least 1.3 m braking distance. It should also be possible to measure each wheel on the same axle separately.

The surface of the plates must admit a friction coefficient between plate and tire of at least 0.8 under dry conditions and 0.6 under wet conditions.

D.2.2. *Accuracy*

The maximum error at any point and any load between 0 and maximum load stated by the manufacturer must not exceed + 5 % of the actual value and + 3 % of the full deflection. The maximum error requirements do not indicate a stricter condition than the resolution requirements below.

When the brake force for each wheel of an axle is the same, the indication from both measuring devices must not differ by more than 2.5 % of the highest indication and maximum 1.5 % of full-scale deflection.

The resolution shall be equal to or better than 20 N.

The measurement system must not be influenced by electromagnetic interference. The plate brake tester including all possible peripheral equipment shall comply with the stated accuracy and with the EMC directive 89/336/EEC.

The manufacturer of the tester must state in which temperature range the accuracy is warranted. The temperature range should be stated on the instrument in a visible place (e.g. date plate).

The temperature tests in the stated temperature range are performed according to OIML ID 11.

D.2.3 *Dynamic test*

The measuring plate is pushed (or pulled) loaded with half the maximum load as stated by the manufacturer. The push (or pull) force is recorded and compared with the force recorded by the plate brake tester. During this test the force readings may not exceed 4 times the maximum error. Alternatively the test is performed by injection of electric signals at an appropriate point of the input

circuitry. The maximum error in the time should not exceed 0,1 s. The reaction time of the plate brake tester shall be less than 0,1 s.

The manufacturer must provide a comprehensive instruction manual with adequate information.

D.2.4 *Software*

The software must be secure against accidental changing of variables influencing the measured values (e.g. calibration factors) by the user. A security code is an acceptable solution.

D.2.5 *Calculation of the test result*

The brake force shall be calculated as a RMS (Root Mean Square) brake force.

D.2.6 *Point zero*

It must be possible to set the zero point of the brake force display manually or it must be set automatically.

D.2.7 *Calibration*

It must be possible to calibrate the plate brake tester over the full measurement range with a suitable device. The accuracy of the calibration device must be better than + 1 % of the actual calibration force.

D.2.8 *Measurement frequency*

The measured values that are the basis for the calculated test result shall be collected with a frequency of not less than 100 Hz. Anti-aliasing filters shall be provided.

D.2.9 *Testing speed*

The test speed is approximately 10 km/h but it must be possible to use higher speeds e.g. for testing antilock systems (ABS).

D.2.10 *Presentation of the test result*

The presentation of the final result of the brake test shall include:

* Brake force for each wheel (N)
* Difference between left and right wheel of front and rear axle (%)
* Deceleration by the service brake at the actual weight (1) (m/s^2)
* Brake forces versus time for each wheel in a diagram (N/s)
* Brake forces for the parking brake (N)

The results can be presented on a display or as a printout. In the former case the results must remain on the display for at least 15s.

The results shall be stored until the next test starts.

It is recommended that the computer automatically compares the test results with the legal limits and presents the final result (approved/failed) for:

* Uneven braking effect
* Deceleration
* Parking brake

Note: For these calculations, the vehicle weight is required. It is recommended that there is a built in weighing device available as a recommended option. If a built in weighing device is not specified, it must be possible to enter the actual or estimated vehicle weight.

D.2.11 Optional supplementary features

The following features should be available for the use in conjunction with the plate brake tester.

1. Pedal force meter indicating the maximum pedal force used.

2. Supplementary presentation of the test results:

   * Pedal force versus time (N/s)
   * Brake force versus pedal force (N/N)
   * Deceleration versus pedal force ($m/s^2/N$)

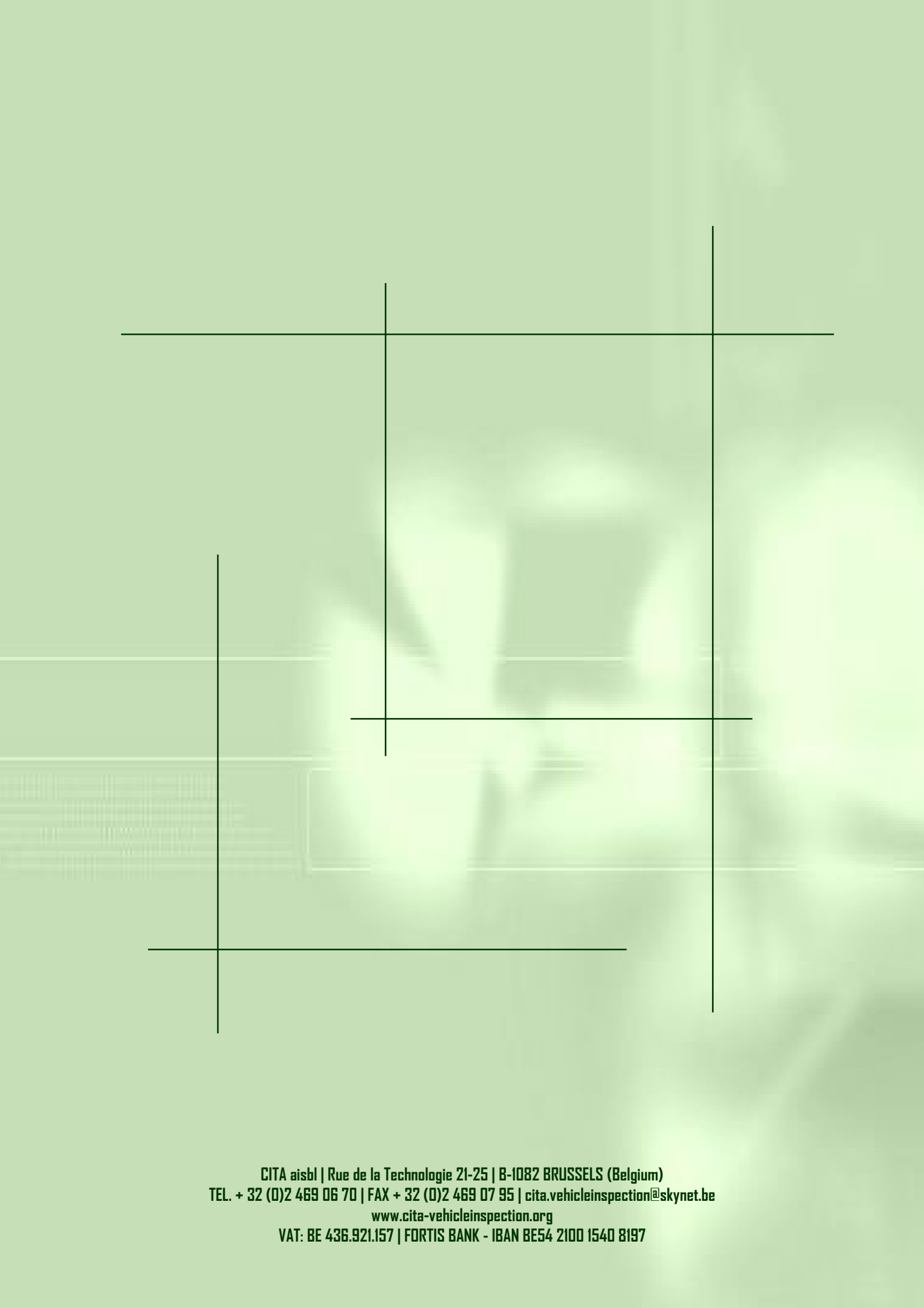
D.3. EDUCATION

Users of plate brake testers must have an adequate education and be familiar with the manufacturer's manual.

ANNEX E

UNITS TO RECOMMENDED FOR USE ON BRAKE TESTING EQUIPMENT

Measurement	Basic units	Prefix of basic units	Alternative units
Brake force	N	daN, kN	kgf, lbF
Air pressure	bar	kPa, Mpa	psi
Weight/vertical force	kg	t	N, daN, kN, lb
Pedal force	N	daN, kN	kgf, lbF



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