HEAVY TRAILER BRAKE COMPATIBILITY

By W. R. LAW

SYNOPSIS

The paper reviews aspects of braking in transport vehicles.

In braking terms some heavy trucks match their trailers and some do not, so that imbalance can occur when units are mixed.

In a modern fleet this is not acceptable, neither from the aspect of durability, nor safety.

An interface standard is needed, to which a truck supplier or a trailer builder can aim separately and later verify, in a straight forward manner.

A comparison of basic physical qualities in the brake system followed by road test, based on optimum retardation, is necessary.

A recommended practice drawing on salient features of overseas standards may achieve brake compatibility between truck and trailer. Documentation should be minimal and a voluntary basis for compliance is preferred.

The paper sets out such a recommended practice which may lead to a New Zealand Standard or appropriate Legislation.

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W.R. LAW

HEAVY TRAILER BRAKE COMPATIBILITY

Introduction

WHY A N.Z. CODE OF PRACTICE?

More performance is now being demanded of transport vehicles, more payload and more stamina.

Since there has been an upward trend in truck power the resultant increase in average speed must obviously impose more strain on the braking system.

We have, as a result, a potential safety problem.

What is not so obvious is that a brake system set up for maximum deceleration will not give an even distribution of braking effort at lighter rates of deceleration which are the more frequent and relate more to brake wear.

Added to this problem is the distribution of loading through the suspension system during the braking process. The most widely used type of suspension for trailers has a poor reaction characteristic, in this respect.

The single point of control of the service brake system is the valve operated by the driver's right foot. The trailer brake system is entirely subservient to the truck and whatever the message passing through the connections is what the trailer must respond to. There is little the trailer brake system can do to modify this message, with the equipment in general use.

The trucks in service in New Zealand will be designed to comply with the standards of the country of origin. It is by no means certain that these standards are identical in effect so far as the trailer is concerned. Furthermore, it may be possible for a truck to exceed the national standard for braking performance.

As a consequence, within a fleet, certain prime movers are well matched to particular trailers. It is relatively easy to balance dedicated units but it does not follow that when units are mixed the balance is maintained.

If one part of the combination has a greater proportion of the braking effort than the other the wear rates will be different, overheating may occur and safety is impaired.

As an industry we have an obligation to provide braking systems which allow for complete interchangeability.

Fleets will be able to operate with greater flexibility and ultimately with more efficiency. Safety will be maintained.

It is noted that in submissions on the subject of possible increased gross combination weight to 44 tonnes, specific reference is made to improved standards of braking as a pre-requisite.

The function of a recommended practice is to interpret the effect of the national Code on the trucks performance. It is fair to say the trailer specification is more likely to be affected, simply due to the greater level of local manufacture.

None of the truck importers relish the prospect of radical changes to trucks as supplied.

What Should the Code Cover?

By limiting the scope to just those vehicles which operate at Class 1 axle loadings and employing "2 line" air pressure brakes, a simplified recommended practice can be compiled which should suffice.

The success of the proposal will depend on selecting the salient points involved without over simplifying the issue.

It is not the intention to require extensive testing or documentation. The transport industry does not have the recourses to duplicate the requirements of Australian Design Rules 35 and 38 certification, for example. This standpoint can be justified by acknowledging 35 and 38 as a reference. In many cases comparable equipment will be employed. Where documentary evidence of the fact exists, further testing is a waste.

The key point is the rate of deceleration.

The aim is to provide a system whereby each part of the combination operates to carry its own share of the braking effort, i.e.,the truck retards itself and the trailer retards itself. During the braking process there should be no net longitudinal force at the coupling. It should make little or no difference to braking performance whether the truck has a trailer or not. The road-using public demands this state of affairs.

The principle will be utilised later in describing a test.

If it can be established what the optiumum retardation of a truck should be, this will be the ideal interface standard.

For true interchangeability all trucks should have the same rate of deceleration, furthermore they should deliver to the trailer at that moment, a pressure signal of known level.

It is noted in the ECE Regulation 13 and the ADR's there is a band of performance for various pressures.

It is suggested that compliance with our recommended practice will be achieved by a single test point, falling between set limits.

It will also be necessary to list certain other external requirements such as coupling location etc.

The recommended practice refers basically to trailers, rather than trucks for the reasons given above, but since trucks are sold for the purpose of pulling trailers there is an obligation to ensure that they are capable of controlling the combination.

A suggested procedure is described in an appendix.

Care should be taken to treat these rules as a Recommended Practice rather than a mandatory requirement. With development and experience, later legislation could well draw on successful acceptance of some of its parts

There is some uncertainty about the selection of a rate of deceleration. One of the questions not satisfactorily assessed is the rather broad tolerance in lining friction grade. A Code should allow for this situation.

Typical lining grades in current use have coefficients of friction as measured by SAE J866A.

Grade EE	0.25 to 0.35
Grade FF	0.35 to 0.45

If a truck has FF at the high end of the scale and the trailer EE at the low end an 80% variation in braking force is possible.

Such a variation would be beyond the ability of a driver to modulate.

As a final comment, despite the high ratio of laden weight to unladen weight in most trailers, experience has shown that if brakes are balanced in the laden condition they can be controlled by a skilled driver in the unladen condition to an acceptable level. It is acknowledged that there exists systems which automatically prevent skidding and no doubt wider use of such devices will be seen in future.

W.R.LAW

RECOMMENDED PRACTICE
HEAVY TRAILER BRAKE COMPATIBILITY

Draft No. 2 August 1985

CONTENTS

(A) RECOMMENDED PRACTICE

The intention of this Code is to specify those aspects of truck and trailer air brake systems which ensure safe braking performance under normal and emergency conditions.

(B) APPENDICES

Appendix 1. Definitions of all of the terms used.

Appendix 2. Describes an appropriate method of testing

(a) reaction time
(b) service brake performance
(c) emergency brake performance
(d) parking brake performance

Appendix 3. Specifies the requirements of components and materials used e.g

control valves
hardware
tubing
hoses
air reservoirs

Specifies the requirements of friction materials.

Appendix 4. Specifies the requirements for installation of the brake system, referred to in Section 5 of the Code.

Appendix 5. Example of simulator.

Appendix 6. Determination of the "Brake Factor" (a preliminary examination prior to testing).

RECOMMENDED PRACTICE

1.0 Definitions See appendix 1

2.0 Design Requirements

2.1 Codes

Recognised Codes such as ADR 35, ADR 38, FMVSS 121, ECE Reg 13 are acknowledged as the basis of sound braking systems and vehicles complying with any of them should be regarded as meeting the requirements of this Code.

The national Codes will be referred to subsequently as approved Codes.

The requirements of the N.Z Goods Service Vehicle Regs must still be met.

2.2 Systems

This code is to apply to vehicles using compressed air as the means of application of the service brake (2 line system). The emergency application may be provided by mechanical means e.g a spring or suitably stored air pressure or a combination of both.

The service brakes must be fitted to and effective on all axles of the combination and be applied in unison by a single action of the drivers foot pedal. Separate control of the trailer brake by manual lever in addition is acceptable but this should not be preferred to application in unison through the foot control. This separate control need not be progressive in action.

2.3 Compressor

Capacity of compressor is as specified in N.Z. Goods Service Vehicles (Construction) Regulations 1936 Amendment No.2 October 1970, including truck and trailer systems. For the purposes of this Code minimum working pressure to be 650Kpa.

2.4 Reservoirs

The tractor reservoirs should have a combined volume of 12 times the full stroke volume of the actuators. The trailer service reservoirs should have a combined volume of 8 times the full stroke volume of the actuators.

2.5 Tractor Protection

The towing vehicle should be equipped with a system which protects the system from a loss of air in the trailer if the pressure falls below 50% of working pressure.

2.6 Couplings

Brake couplings should be of the handed type, either the single piece MANCO WABCO or the ISO/US Palm type, permitting full flow of air.

The coupling point for full trailers should be close to the centre line of the towing vehicle but below and to the right of the towing hitch (jumper hoses part of the trailer).

The service line (control) should be towards the right hand side and the emergency line (supply) to the left, when looking forward (as in SAE J849b).

3.0 SERVICE SYSTEM

3.1 Actuation Time

Actuation time is to be measured from the first movement of the brake control. An alternative is that moment when pressure in the supply to the control valve drops on actuation of the valve.

The control line (service) pressure rise, measured at the end of a line 2.5 metres long incorporating a 800ml test reservoir connected to the towing vehicles brake couplings shall be 0.0KP to 65% of final pressure in less than 0.22 sec. A simulator with these characteristics may be employed to test a trailer.

With a trailer connected normally the pressure rise in least favoured axle of the trailer shall be from 0.0KPa to 65% of final pressure in less than 0.35 sec.

If the trailer pulls a second trailer the pressure rise measured at the towing unit brake couplings shall be from 0.0KPa to 65% of final pressure in less than 0.25 sec.

3.2 Release Time

The release time to be that interval from the moment of release of the brake when pressure falls from 61KPa to 30KPa, and shall be for

(a) least favoured axle, 0.65 sec
(b) dolly or towing unit, 0.55 sec

RECOMMENDED PRACTICE

4.0 EMERGENCY SYSTEM

4.1 Emergency Actuation

The brake system should incorporate an emergency system which can be activated independently from the service brake control in the event of loss of air.

4.2 Park Brake

Where a trailer has auxilliary park brake release device it must be such that the brake system is restored automatically on resumption of supply from the towing vehicle.

4.3 Emergency Brake Release

Means of releasing the emergency brake are to be incorporated provided the brake can be re-applied from this control immediately. Service brake air pressure may be utilized for this purpose provided more than one release can be made from the reserve at normal working pressure.

5.0 PERFORMANCE

5.1 Service Brake

The trailer service brake system shall either

(a) Comply with approved Codes

or (b) By means of calculations satisfactory to MOT demonstrate the ability to stop from a speed of 30KPH with a deceleration of 0,5g. Wheel lock-up of one axle of the truck and one axle of the trailer is permitted. Skid test data to be provided.

or (c) By means of road test or suitable chassis dynamometer demonstrate the ability to comply with the stopping distance of Traffic Regs 1976 Reg 68 (laden condition). No limitation on wheel lock-up.

5.2 Emergency Brake

The trailer emergency brake system shall either

(a) Comply with approved Codes

or (b) By means of calculations satisfactory to MOT demonstrate the ability to stop from a speed of 30KPH with a deceleration of 0.30g. Wheel lock-up of one axle of the truck and one axle of the trailer is permitted. Skid test data to be provided.

5.3 Parking Brake

The trailer parking brake system shall either, when fully laden

(a) Comply with approved Codes

or (b) By means of calculation satisfactory to MOT demonstrate capability of holding the laden vehicle on a slope of 20% in either direction.

or (c) By means of test (road or dynamometer) demonstrate the ability to hold the vehicle on a slope of 20% in either direction.

6.0 COMPLIANCE

6.1 Each trailer being presented for approval shall carry a permanent unique label certifying that it complies with the provisions of this recommended practice.

6.2 Certification shall include a statement by a responsible person approved by MOT, that all materials and components, employed in the brake system are of an approved standard and that the design of the system, including tubing size and maximum tubing lengths is to a layout approved by the MOT.

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APPENDIX 1

Definitions

The following list extracted from ADR 38 is included as an example of terms likely to be employed in a N.Z Code. There may be minor changes due to local useage.

38.1 Definitions

38.1.1 Administrator - means the Australian Motor Vehicle Certification Board or a person to whom the Board has delegated, by instrument in writing revocable at will, the powers and functions of the Administrator under this rule.

38.1.2 Antilock System - means a portion of a Service Brake System that automatically controls the degree of rotational wheel slip relative to the road of one or more road wheels of the trailer during braking.

38.1.3 Approved Brake System - is a Brake System that has been certified by the administrator on the basis of it having been shown to meet the requirements of this Design Rule.

38.1.4 Average Retardation Coefficient - is the average braking deceleration, from initial movement of the brake control to the trailer becoming stationary, expressed as a proportion of the acceleration due to gravity.

38.1.5 Axle Load - is the sum of the forces due to gravity exerted by the wheels attached to any individual axle when resting on a horizontal supporting plane.

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38.1.6 Brake System - means all those systems and devices attached to the Trailer whose primary function is to translate energy and or information supplied by the towing vehicle into a force that restrains Trailer movement.

38.1.7 Brake Device - means one element of the Brake System that may consist of more than one part but which is designed to perform one or more discrete functions.

38.1.8 Brakes - means those friction elements that are forced together by the influence of the remainder of the Brake System so as to apply a restraining torque to the Trailer wheels.

38.1.9 Control Line - means the device that transmits the control signal from the towing vehicle to the first other device, or between other devices on the Trailer as a boosted or relayed signal not involving significant amounts of Stored Energy transfer. (Often called the service line the the case of compressed air brake systems).

38.1.10 Control Signal - means the signal that is provided by the towing vehicle to the Trailer for control of the Service Brake System in normal operation.

38.1.11 Control System - means all the Brake Devices between the trailer Brake System couplings (supply and control) and the Brakes actuators.

38.1.12 E - is a nominal unit of Control Signal strength. For the purposes of this rule 1.0 E has been equated to the Normal Minimum Energy Level of compressed air brakes which, for Trailers, has been nominated as 650KPa.

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Values appearing in brackets after E values in this rule are the equivalent KPa values for compressed air Brake Systems. The relationship between E and other brake control mediums has not been set in this rule.

38.1.13 Emergency Brake System - means that part of the Brake System that is controlled by a line other than the Control Line and which automatically applies in the event of Trailer break-away.

38.1.14 Established Retardation Coefficient(ERC) - is the average braking deceleration calculated from when the energy level in the Brakes actuator reaches its final value to when the Trailer becomes stationary, expressed as a proportion of the acceleration due to gravity.

38.1.15 Foundation Brakes - means the Brakes and associated mechanical parts supplied as a unit and which are usually incorporated into a Brake System design without change.

In the case of an S - cam air Brake System - the camshaft would be included but not the slack adjuster and actuator.

38.1.16 Gross Axle Load Rating (GALR) - means the manufactures specified maximum Axle Loading for each axle for which compliance with applicable Australian Design Rules has been or can be established.

38.1.17 Group Gross Axle Load Rating (GGALR) - means the least of the values allowed by GALR, Table 1 or that determined by GTMR.

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38.1.18 Gross Trailer Mass Rating (GTMR) - means the manufacturers specified maximum loaded trailer mass for which compliance with applicable Australian Design Rules has been or can be established.

38.1.19 Loaded Test Mass (LTM) - means the mass of the laden Trailer when loaded such that each of its axle groups is loaded to the specified GGALR's.

38.1.20 Maximum Loaded Test Mass (MLTM) - means the mass of the laden Trailer loaded to GTMR with the load distributed approximately uniformly over the load bearing area such that the Trailer Axle Loads do not exceed the Trailer manufacturer's nominated individual axle loads (GALR).

38.1.21 Lightly Laden Test Mass (LLTM) - is the mass of the Trailer in its normal unladen condition.

38.1.22 Normal Minimum Energy Level - is the normal operating minimum level of the energy storage devices as defined by the normal cut-in level of the storage charging system and in the case of a compressed air Brake System, shall be taken as 650KPA.

38.1.23 Parking Brake System - means that the part of the Trailer Brake System which is able to apply and maintain a restraining force at two or more trailer road wheels with and without the Trailer being separated from the towing vehicle.

38.1.24 S - Cam - means a foundation brake unit which utilises the rotation of an S shaped cam to actuate the brakes.

APPENDIX 1

38.1.25 Service Brake System - means the Brake System which in proportion to the Control Signal, applies a restraining torque to the Trailer wheels in normal operation.

38.1.26 Skid Limit - means the degree of braking at which wheel lock-up commences.

38.1.27 Spring Brake System - means a Brake System utilizing one or more springs to store the energy required to actuate the Brakes.

38.1.28 Stopping Distance/Time - means the distance/time from initial movement of the brake control to the Trailer becoming stationary.

38.1.29 Stored Energy - means energy stored in a device such as a pressure vessel, vacuum chamber, spring or battery.

38.1.30 Stored Fluid Energy - means energy stored as compressed air, in hydrualic accumulators, or as any form of electrical energy.

31.1.31 Supply Line - means the path by which any stored energy required to actuate/release the Trailer Brakes is supplied from the towing vehicle connection to the first other device in the Trailer Brake System. (Normally referred to as the emergency line in a 2 line compressed air Brake System).

APPENDIX 1

38.1.32 Trailer - means semi, dog and pig trailers, see note, below

- a semi trailer is one having an axle group toward the rear;
- a dog trailer is one with two axle groups of which the front axle group is steered by connection to the towing vehicle;
- a pig trailer is one having one axle group near the middle of the length of the goods carrying surface.

38.1.33 Trailer Gross Axle Load Rating (TGALR) - means the sum of the GALR of each axle attached to the Trailer.

38.1.34 Total Combination Mass - means the combined mass of the laden or unladen trailer and the towing vehicle.

38.1.35 Total Trailer Axle Load - is the total force exerted by the individual axles attached to the Trailer when resting on a horizontal supporting plane.

38.1.36 Unique Braking System - means a Brake System consisting of a particular combination of components with particular physical and dimensional properties.

38.1.37 Variable Proportioning Brake System - means a Brake System that automatically adjusts the braking force at an axle to compensate for Trailer static Axle Load and/or dynamic weight trasfer between axles during acceleration and deceleration.

NOTE New Zealand Terminology

Semi Trailer

Full Trailer

Fixed Drawbar Trailer.

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APPENDIX 2

Methods of Testing

(a) Reaction Time

For the test the trailer may be connected to a truck in a normal way or to a simulator as described in ADR 38 or the EEC directives. In either case the pressure rise interval at the end of the test volume of 800ml capacity connected to the service coupling should be as per 3.1. An electrical timing device with pressure operated switches should be used or alternative a pedal operated switch which determines the moment of brake application or the moment of brake release, with the electrical pressure switch indicating the end point of the pressure change required. As noted in the ADR 38 a pressure switch in the supply line to the control valve may be employed, utilizing the momentary pressure drop as the control valve is opened to trigger the timer.

(b) Service and Emergency Brake Testing

Most axle equipment in service in New Zealand appears to be of imported types and in all probability are thereby approved according to a recognised Code in the Country of origin. The option to test to ADR 38 etc must be recognised and commended, however.

It is regarded as vital that componentary be utilised in a fashion which does not diminish safety aspects.

APPENDIX 2

In view of the possiblity of loss of directional control due to brake lock-up an upper limit of brake power is appropriate.

It may become necessary in the future for the Ministry of Transport to require evidence of the trucks ability to operate with a trailer, including appropriate brake control.

The capability of the truck then becomes a suitable reference for the demonstration of the capability of the trailer.

It is proposed that the manufacturers or assemblers of trucks or trailers conduct a "type test" for approval. The purpose of this is to demonstrate the ability to perform a controlled stop without loss of directional stability.

The "type test" truck would perform such a test laden and in the case of a semi trailer combination, with a semi trailer. In the case of a full trailer, without the trailer.

For the truck test a deceleration of not less than 0.45g and not more than 0.6g from a speed of 30KPH must be achieved with the vehicle remaining substantially in a straight line. At this deceleration the pressure in the trailer control line must be 650KPa $\pm$ 65KPa.

For the tractor test, the semi trailer should be loaded in such a way that the GALR of the tractor is achieved. The trailer brakes will be disconnected,

APPENDIX 2

The deceleration obtained by tractor brakes alone to be not less than

$$0.45g\left(\frac{\text{GALR (tractor)}}{\text{GCW (as tested)}}\right)$$ and not more than $0.6g\left(\frac{\text{GALR (tractor)}}{\text{GCW (as tested)}}\right)$ with the control line pressure at 650KPa $\pm$ 65KPa.

In both of these tests not more than one axle may lock up (in each unit).

With trailer coupled and semi trailer loaded to produce the GALR of the trailer axles the test is repeated and the deceleration should not be 10% greater than or 10% less than previously achieved.

(c) Emergency Brake Performance

In order to test the ermergency brake system performance the above sequence should be repeated using emergency brake only in which event the deceleration achieved should not be less than 0.3g.

(d) Parking Brake Performance Tests

This test may be carried out on a grade of 20% in with the vehicle facing either direction first separately and then together or alternatively by measuring the deceleration from 30KPH with

(a) tractor parking brake operating

(b) trailer parking brake operating.

APPENDIX 2

The deceleration,shall be not less

than $0.196g \left(\frac{\text{gross wt of tractor}}{\text{gross comb. wt}}\right)$ for (a)

and $0.196g \left(\frac{\text{gross of trailer}}{\text{gross comb wt}}\right)$ for (b)

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APPENDIX 3

Materials and Components

All materials and components to be to a recognised standard e.g. SAE, DIN, JIS etc.

Tube fittings (threaded) may be either metric standard or Imperial standard but should not be mixed in any one system.

Control valves to be of a recognised make and type, in general use in the Country of origin and specifically designed for air brake application.

Air reservoirs to be manufactured and tested to SAE J10 or equivalent and in particular be adequately protected from corrosion. Actuators (service) to be of diaphragm type and of a volume as measured by SAE J1155.

Friction Materials

Friction materials must be identified and certified as being capable of achieving the performance standards of ADR 38 etc in all respects (ref ASE J866a, J840c, J998) e.g fade performance, water performance etc.

The purpose of this requirement is to avoid the extensive testing which would otherwise be required,

The manufacturer of the brake drum must also approve of the use of any lining so identified.

Documentary evidence of meeting this criteria should be provided.

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APPENDIX 4

Brake System Installation

A circuit diagram for any brake system should be provided for approval to ensure that the requirements of the Regulations are met.

This may be done in two stages

(a) basic circuit

(b) permitted variations in number of components, sizes of tubing, actuators, reservoir capacity etc and arrangement of same.

In this way it should not be necessary to submit a diagram for every vehicle type produced.

The circuits should be designed and installed to take full advantage of the operating characteristics of the equipment including

optimum tubing diameter

control valves preferably directly mounted on reservoirs

minimum of elbows and other restrictions on air flow, especially on the control line

mount actuators for best leverage

avoid excessive use of sealants, which might enter the working chambers of control valves and effect their function

support the fixed lines adequately and route flexible lines to avoid chafing.

In general, nylon or metal tubing may be used for fixed lines provided the corresponding compression screwed fittings are employed.

APPENDIX 4

Rubber hose is normally required for flexible lines but approved flexible coiled plastic tubing may be used for jumper lines for semi trailers. Coiled jumper lines should not be used for full trailers.

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APPENDIX 5

Example of Simulator

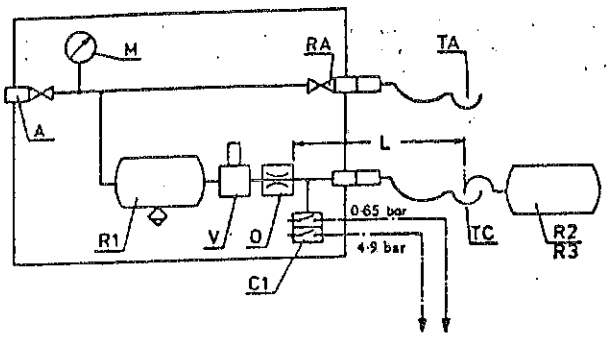
D: ION.	E.C.E.	REGULATION NO. 13	INDEX: 10.01 10.10
RCE: LLE: RCE		Date of issue: Ausgabedatum: Date d'edition:	

ANNEX 6 - APPENDIX 1

EXAMPLE OF A SIMULATOR

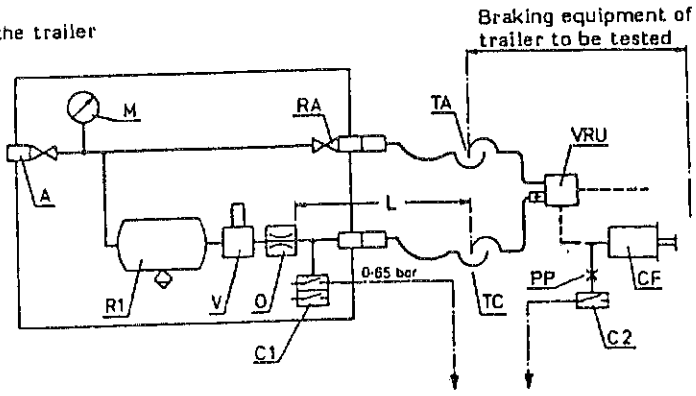
(see Annex 6, Paragraph 3)

1. Setting the simulator



To the electric chronometer

2. Testing the trailer



To the electric chronometer

APPENDIX 5

COUNTRY / LAND / NATION: E.C.E.	ORIGINAL: REGULATION NO. 13	INTEREUROPE
SOURCE / QUELLE / SOURCE	Date of issue / Ausgabedatum: / Date d'edition:	INDEX: 10.01 10.10

A = Supply connection with shut-off valve.

C1 = Pressure switch in the simulator, set at 0,65 bar and at 4,9 bar.

C2 = Pressure switch to be connected to the brake actuator of the trailer, to operate at 75 % 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 6,5 bar.

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 1155 ± 15 cm^3.

RA = Shut-off valve.

TA = Coupling head, supply line.

TC = Coupling head, control line.

V = Braking control device.

VRU = Emergency relay valve.

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APPENDIX 6

Brake Factor

As a preliminary to testing it is possible to compare the physical characteristics of the truck and trailer when described as a factor.

Under braking, without skidding, the minimum retarding torque produced must equal the friction force betwen road and tyre multiplied by the rolling radius.

This can be stated

$$R_T \times W \times U_R = K \times P \times A \times L \times U_L \times R_D$$

Where K is a constant relating to cam shape and mechanical losses
R_D is drum radius
L is slack adjuster lever length
U_L is friction coefficient of lining
A is actuator area
R_T is tyre radius
W is axle load
P is air pressure
U_R is friction coefficient tyre/road

It is assumed that the geometry of the truck foundation brakes is similar to that of the trailer. If the pressure rise in the trailer actuators matches that of the tractor, we can say for comparative purposes:

$$\text{Brake Factor} = K \times \left(\frac{R_D \times L \times U \times A}{R_T \times W}\right) \times P$$

The item U_R can be neglected as this will be common to truck and trailer

APPENDIX 6

Example

Truck has

Axle load	7250kg	
Tyre size	11R 22.5	R_T = 50.0
Drum size	16½ x 7	R_D = 20.9
Lever length	6" slack	L = 15.2
Actuators	Type 24	A = 155cm^2
Lining grade	SAE 'FF'	μ = 0.4

Trailer has

Axle load	6000kg	
Tyre size	255.70R 22.5	R_T = 43.2
Drum size	16½ x 7	R_D = 20.9
Lever	6" slack	L = 15.2
Actuator	Type 30	A = 194cm^2
Linings	SAE 'EE'	μ = 0.3

For a given pressure

Truck

$$\text{Brake factor} = K\left(\frac{20.9 \times 15.2 \times 0.4 \times 155}{50 \times 7250}\right) = 0.054 \times K$$

Trailer

$$\text{Brake factor} = K\left(\frac{20.9 \times 15.2 \times 0.3 \times 194}{43.2 \times 6000}\right) = 0.071 \times K$$

Comment

If actuator size reduced to type 24

Trailer factor = 0.056 x K i.e a better match is obtained.