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EAST AFRICAN STANDARD

Motor vehicle safety specification — Braking — Part 6: Distribution of braking effort and compatibility of vehicles in combination

EAST AFRICAN COMMUNITY

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Foreword

Development of the East African Standards has been necessitated by the need for harmonizing requirements governing quality of products and services in East Africa. It is envisaged that through harmonized standardization, trade barriers which are encountered when goods and services are exchanged within the Community will be removed.

In order to meet the above objectives, the EAC Partner States have enacted an East African Standardization, Quality Assurance, Metrology and Test Act, 2006 (EAC SQMT Act, 2006) to make provisions for ensuring standardization, quality assurance, metrology and testing of products produced or originating in a third country and traded in the Community in order to facilitate industrial development and trade as well as helping to protect the health and safety of society and the environment in the Community.

East African Standards are formulated in accordance with the procedures established by the East African Standards Committee. The East African Standards Committee is established under the provisions of Article 4 of the EAC SQMT Act, 2006. The Committee is composed of representatives of the National Standards Bodies in Partner States, together with the representatives from the private sectors and consumer organizations. Draft East African Standards are circulated to stakeholders through the National Standards Bodies in the Partner States. The comments received are discussed and incorporated before finalization of standards, in accordance with the procedures of the Community.

Article 15(1) of the EAC SQMT Act, 2006 provides that "Within six months of the declaration of an East African Standard, the Partner States shall adopt, without deviation from the approved text of the standard, the East African Standard as a national standard and withdraw any existing national standard with similar scope and purpose".

East African Standards are subject to review, to keep pace with technological advances. Users of the East African Standards are therefore expected to ensure that they always have the latest versions of the standards they are implementing.

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Motor vehicle safety specification — Braking — Part 6: Distribution of braking effort and compatibility of vehicles in combination

1 Scope

This part of the specification covers the requirements necessary for the safe braking performance, particularly on road surfaces which have reduced adhesion, of vehicles of categories M, N O_3, and O_4 (see CD/K/039-1:2008) that are not equipped with an anti-lock device. These requirements are for the distribution of braking effort among axles, and the compatibility of such vehicles in combination.

2 Definitions and symbols

For the purposes of this part of the specification, the definitions given in CD/K/039-1:2008 and the following definitions shall apply:

adhesion coefficient
k
theoretical coefficient of adhesion between the tyre and the road

adhesion utilization
ratio of the braking force developed at the wheel to the normal reaction of the road surface during braking

adhesion utilization curve AUC
graph of the adhesion used by an axle plotted against the vehicle braking ratio under a specified load condition

braking ratio
z
except in the case of semi-trailers, the ratio of the deceleration of the vehicle to the acceleration of gravity (see z under 2.2)

laden articulated combination
unladen drawing vehicle that is so coupled to a laden semi-trailer that each vehicle in the combination is at its maximum vehicle mass

semi-trailer
trailer that, when uniformly loaded, imposes at least 20 % of the weight of its load on the drawing vehicle

trailer
any trailer other than a semi-trailer

unladen articulated combination
unladen drawing vehicle coupled to an unladen semi-trailer

unladen vehicle mass
mass of a vehicle, ready to be driven, including a full tank of fuel plus a driver but for this part of the specification excluding an observer and test equipment

For the purposes of this part of the specification the following symbols shall apply:

E wheelbase, metres

E_R distance between king pin and centre of axle or axles of semi-trailer, metres

f_i	adhesion used by axle i = $\frac{T_i}{N_i}$
g	acceleration due to gravity = 10 metres per second^2
h	height of centre of gravity supplied, unless otherwise stated, by the manufacturer, metres
h_0	height of centre of gravity of a drawing vehicle for a semi-trailer, metres
h_R	height above ground of centre of gravity of semi-trailer, metres
h_s	height above ground of the coupling on which a semi-trailer rests, metres
i	axle index (i = 1 for front axle; i = 2 for second axle, etc.)
J	deceleration of vehicle, metres per second^2
k	theoretical coefficient of adhesion between tyre and road
K_c	correction factor for a laden semi-trailer
K_v	correction factor for an unladen semi-trailer
Ni	normal reaction of road surface on axle i under braking, newtons
p_m	pressure at coupling head of service line, kilopascals
P	weight of a vehicle, newtons
P_i	normal reaction of the road surface on axle i under static conditions, newtons
PM	total normal static reaction of the road surface on the wheels of a drawing vehicle, newtons
P_0	weight of unladen solo drawing vehicle, newtons
PR	total normal static reaction of the road surface on the wheels of a trailer or semi-trailer, newtons
PR_{max}	value of PR at the maximum weight of a semi-trailer, newtons
P_s	equivalent dynamic load of a semi-trailer on the drawing vehicle, newtons
P_{so}	difference between the maximum laden weight of a drawing vehicle and its unladen weight, newtons
Ti	force exerted by the brakes on axle i under normal braking conditions on the road, newtons
TM	sum of braking forces at the periphery of all wheels of a drawing vehicle for trailers or semi-trailers, newtons
TR	sum of braking forces at the periphery of all wheels of a trailer or semi-trailer, newtons
z	braking ratio of vehicle = $\frac{J}{g}$ except that for a semi-trailer z = $\frac{TR}{PR}$

3 Construction of adhesion utilization curves (AUCs)

3.1 Vehicles of categories M, N and O_3, and O_4

Except as specified in 3.2 and 3.3, manufacturers shall prepare axle AUCs from the following formulae for the laden and unladen condition for vehicles of categories M, N and O_3, and O_4:

a) Front axle $f_1 = \frac{T_1}{N_1} = \frac{T_1}{P_1 + z\frac{h}{E}P}$

b) Rear axle $f_2 = \frac{T_2}{N_2} = \frac{T_2}{P_2 - z\frac{h}{E}P}$

In the case of laden vehicles other than drawing vehicles for semi-trailers, if provision is made for several possibilities of load distribution, the possibility whereby the front axle is most heavily laden shall be the one for which the laden AUCs are constructed.

3.2 Drawing vehicles for semi-trailers

Manufacturers shall prepare axle AUCs for the front and rear axles of drawing vehicles for semi-trailers according to the load conditions and formulae given in table 1 to allow for the relevant dynamic load transfer from the semi-trailer.

Table 1 — Calculations for drawing vehicle fro semi-trailer (see 3.2)

1	2	3	4	5
Load condition for the drawing vehicle	**Height (h) of centre of gravity of the drawing vehicle m**	**Dynamic load (P_s) transferred to drawing vehicle by semi-trailer onto the coupling king pin N**	**Adhesion utilization***	
			Front axle of drawing vehicle	**Rear axle of drawing vehicle**
Unladen solo	As specified by the manufacturer	$P_s = 0$	$f_1 = \frac{T_1}{P_1 + z\frac{h}{E}P}$	$f_2 = \frac{T_2}{P_2 - z\frac{h}{E}P}$
Unladen articulated combination	$h = \frac{h_0P_0 + h_sP_s}{P}$ where P = P_0+P_s = P_1+P_2	P_s= 15% of the maximum static force on the coupling which would cause the drawing vehicle to be loaded to its maximum vehicle mass	$f_1 = \frac{T_1}{'P_1 + \frac{z(h_0P_0 + h_sP_s)}{E}}$	$f_2 = \frac{T_2}{'P_2 - \frac{z(h_0P_0 + h_sP_s}{E}}$
Laden articulated combination	$h = \frac{h_0P_0 + h_sP_s}{P}$ where P = P_0+P_s = P_1+P_2		$f_1 = \frac{T_1}{'P_1 + \frac{z(h_0P_0 + h_sP_s)}{E}}$	$f_2 = \frac{T_2}{'P_2 - \frac{z(h_0P_0 + h_sP_s}{E}}$

* where $'P_1$ and $'P_2$ = P_1 and P_2 (respectively) modified by a suitable function of P_s that makes allowance for the relevant dynamic load transfer from the semi-trailer.

3.3 Trailers and semi-trailers

AUCs shall not be constructed for the following:

a) trailers not fitted with air brakes, or

b) single-axle trailers, or

c) twin-axle trailers having an axle spread of less than two metres, or

d) semi-trailers.

4 Requirements

4.1 Distribution of braking effort among axles on vehicles of categories M, N, O_3, and O_4

4.1.1 Position of AUCs

The position of axle AUCs constructed in accordance with 3.1 or 3.2 (as relevant) shall be as specified in table 2 and shown in figure 1A and figure 1B for all states of load of the vehicle.

Table 2 — Positions of adhesion utilization curves (AUCs) (see 4.1.1)

1	2	3	4	5
Number of axles on the vehicle	**Vehicle category**		**For braking ratio, z**	**Position of AUC**
Two or more	M, N, O_3, and O_4	a)	Between 0.1 and 0.61	The AUCs for each axle shall be below the line $k = \frac{z + 0.07}{0.85}$ Figure 1B*
Two	Mi	b)	Between 0.15 and 0.8	Except as allowed in (c) below, the front axle AUC shall be above the rear axle AUC
		c)	Between 0.3 and 0.45	Front axle AUC may be below rear axle AUC provided that the rear axle AUC is not more than 0.05 above the line of k = z in Figure 1A
	M_2, M_3, N, O_3, and 64	d)	Between 0.1 5 and 0.3	Except as allowed in (e) below, the front axle AUC shall be above the rear axle AUC
		e)	Between 0.1 5 and 0.3	Front axle AUC may be below the rear axle AUC, provided that the AUCs for each axle are between two parallel lines of k = z ± 0.08 in figure 1B and that the rear axle AUC is below the line of k = $\frac{z - 0.02}{0.74}$ In the range z = 0.3 to 0.61†
More than two ‡.	M, N, O_3, and O_4	f)	Between 0.1 5 and 0.3	The AUC, for at least one front axle shall be above the AUC for at least one rear axle

* Derived from $z \geq 0.1 + 0.85(k - 0.2)$.
† Derived from $z \geq 0.3 + 0.74(k - 0.38)$.
‡ If the requirements given in (f) are not met, those given in (b) and (c) or in (d) and (e), as appropriate, apply.

4.1.2 Failure of braking distribution system

When the requirements of this part of the specification are met by means of a braking distribution system, it shall be possible, in the event of failure of this device or its control, to stop the vehicle under the conditions prescribed in CD/K/039-1:2008 for

a) category M, N vehicles: secondary braking performance;
b) category O_3, O_4 vehicles: 30 % of the specified service brake performance.

4.1.3 Operation of braking distribution system

When the requirements of this part of the specification are met by means of a braking distribution system, the operation of the system shall be automatic.

4.2 Compatibility of vehicles of categories M, N, O_3, and O_4

4.2.1 Trailers and drawing vehicles for trailers

For a trailer or a drawing vehicle for a trailer and that is, in both cases, equipped with air brakes, the relationship between the braking ratio TR/PR or TM/PM, as relevant, and the pressure p_m shall be within the areas shown in figure 2 for the laden and unladen states.

4.2.2 Drawing vehicles for semi-trailers

a) In the case of a drawing vehicle for a semi-trailer that is equipped with air brakes, the relationship between the braking ratio TM/PM and the pressure p_m shall be within the areas shown in figure 3 for the semi-trailer laden and unladen.

b) In addition, the braking forces on the drawing vehicle shall continue to be regulated for the solo-drawing-vehicle state.

4.2.3 Semi-trailers

For a semi-trailer the relationship between the braking ratio TR/PR and the pressure p_m shall lie within two areas derived from figure 4A and figure 4B for the unladen and laden states and for any intermediate load condition on the semi-trailer axles.

4.2.4 Drawing vehicles for trailers or semi-trailers

The pressure at the service-line coupling head of a drawing vehicle for a trailer or a semi-trailer that is, in both cases, fitted with air brakes shall not be affected by the operation of the pressure-regulating devices on the axle of the drawing vehicle.

5 Marking

5.1 When a braking distribution device is necessary to enable a vehicle of category M_2, M_3, N, O_3, or O_4 to meet the requirements of this part of the specification, the following information shall be stamped or indelibly printed on a plate affixed to the vehicle in a position readily accessible to an inspector:

a) for devices mechanically controlled by the suspension of the vehicle: the useful travel of the device between the positions corresponding to the laden and unladen states together with the length of the lever arm;

b) for devices actuated by compressed air: the pressure values attained at the outlet of the device during full braking under both laden and unladen states.

6 Inspection and methods of test

6.1 AUCs

Inspect the AUCs and carry out any further tests necessary to ensure that the AUCs have been prepared as required in clause 3 and that their positions comply with the requirements of 4.1.1.

6.2 Braking distribution system

6.2.1 Failure test

Where a braking distribution system is required for the purposes of this part of the specification, simulate a failure of the device or its control and check for compliance with 4.1.2 by

a) calculation, or

b) testing in accordance with the relevant clause of CD/K/039-1:2008.

6.2.2 Operation

Operate the device and check for compliance with 4.1.3 and 4.2.4.

6.2.3 Marking

Examine the markings provided on the vehicle for compliance with the requirements of 5.1.

6.3 Brake roller-dynamometer tests

Test the vehicle on a roller-dynamometer and by determining its mass and examining dynamic test results, obtain data to assess compliance with 4.2.2(b) and to construct graphs to verify, using Figures 2, 3, 4A and 4B, and appendix A, compliance with 4.2.1, 4.2.2(a) and 4.2.3, as relevant.

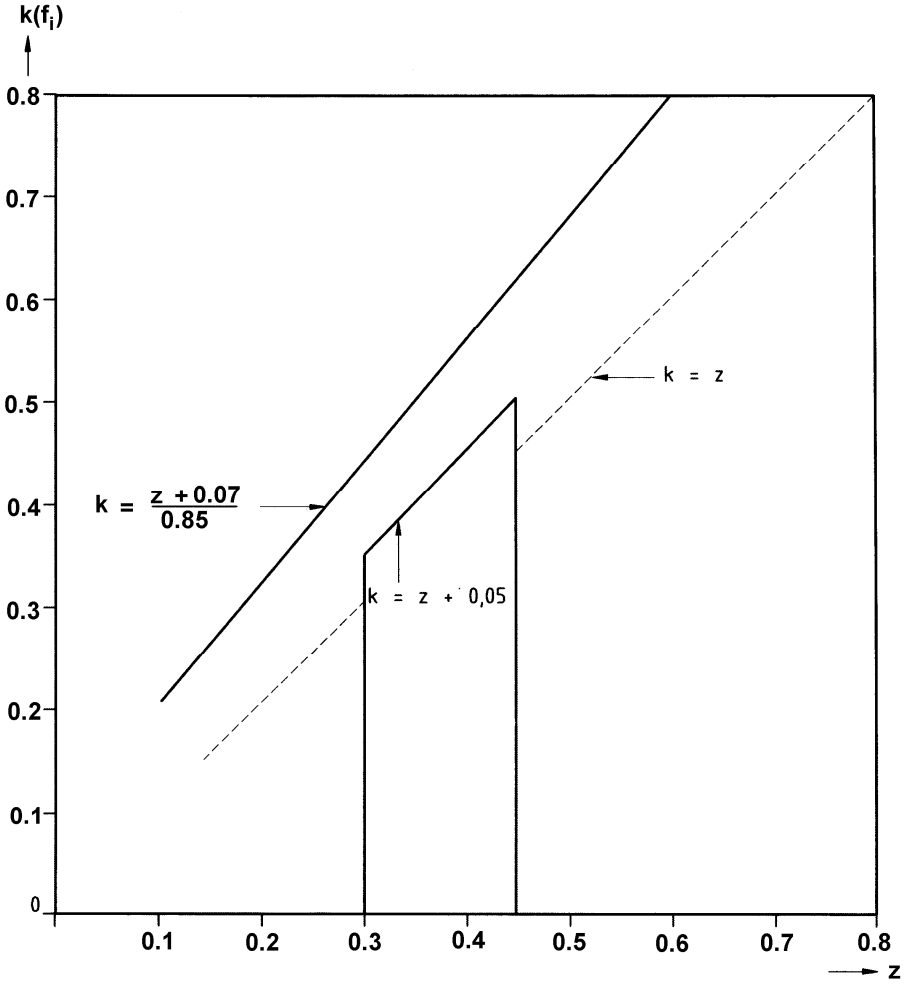


Figure 1A — Vehicles of category M, (see 4.1.1 and table 2)

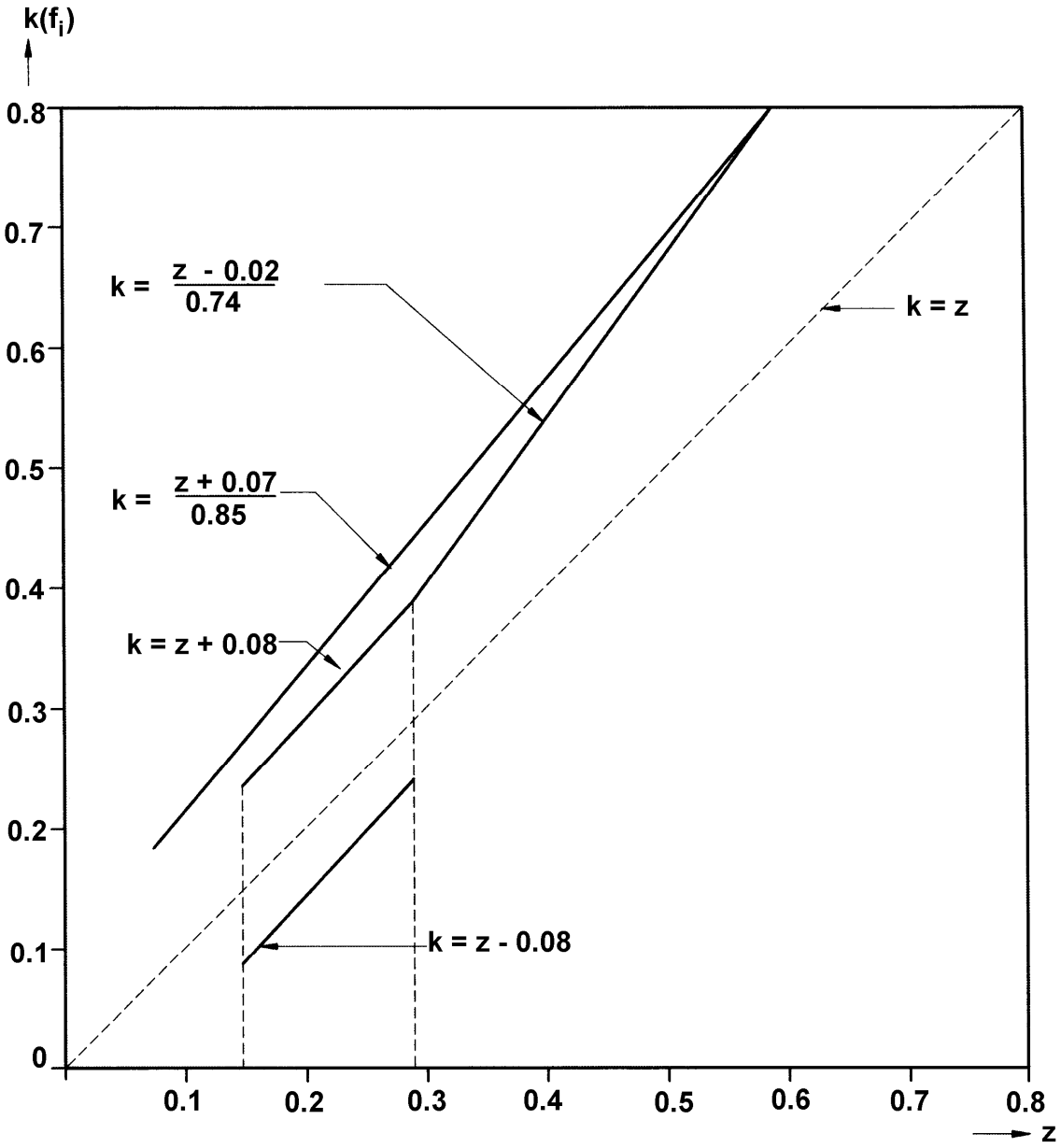
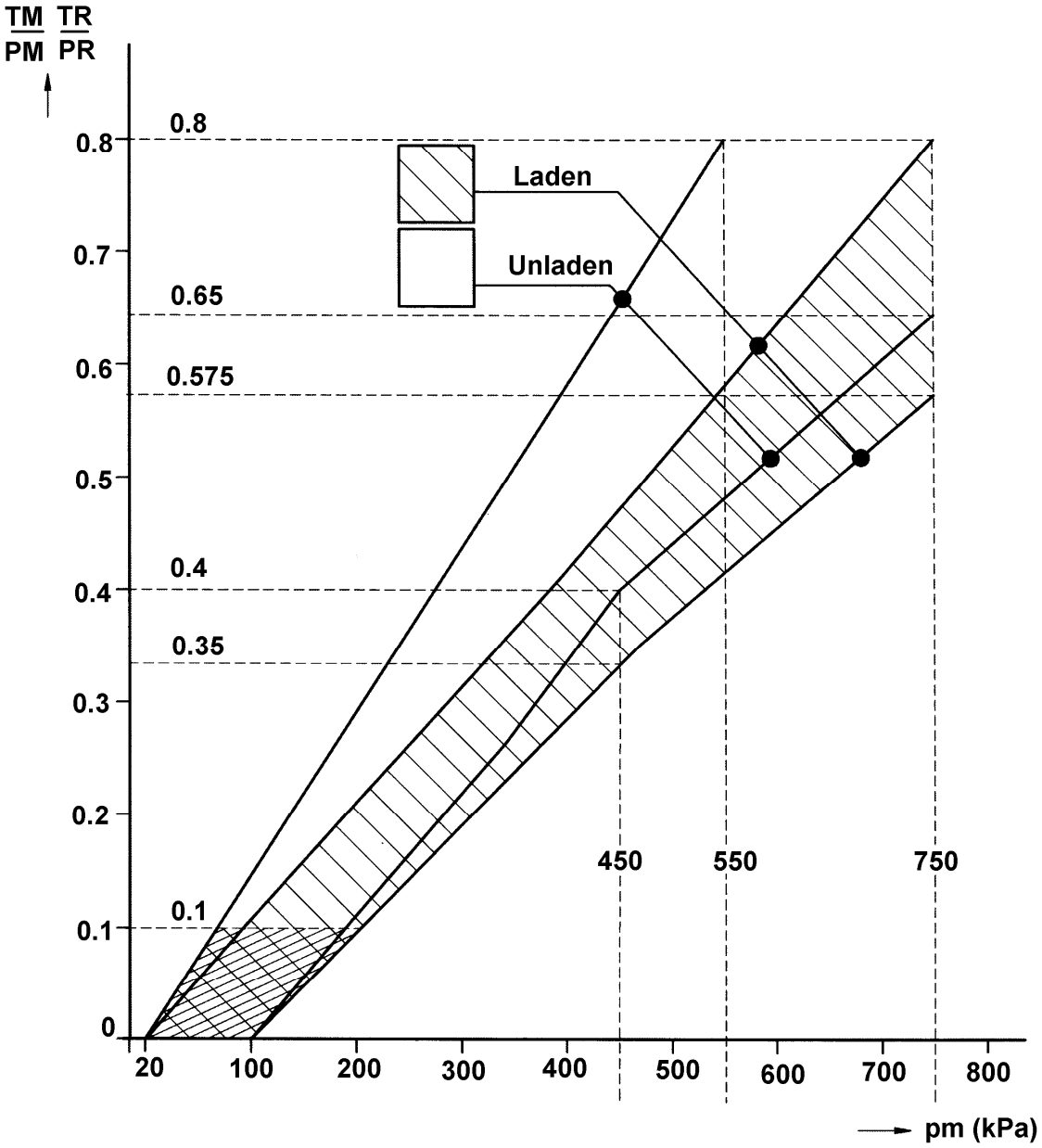
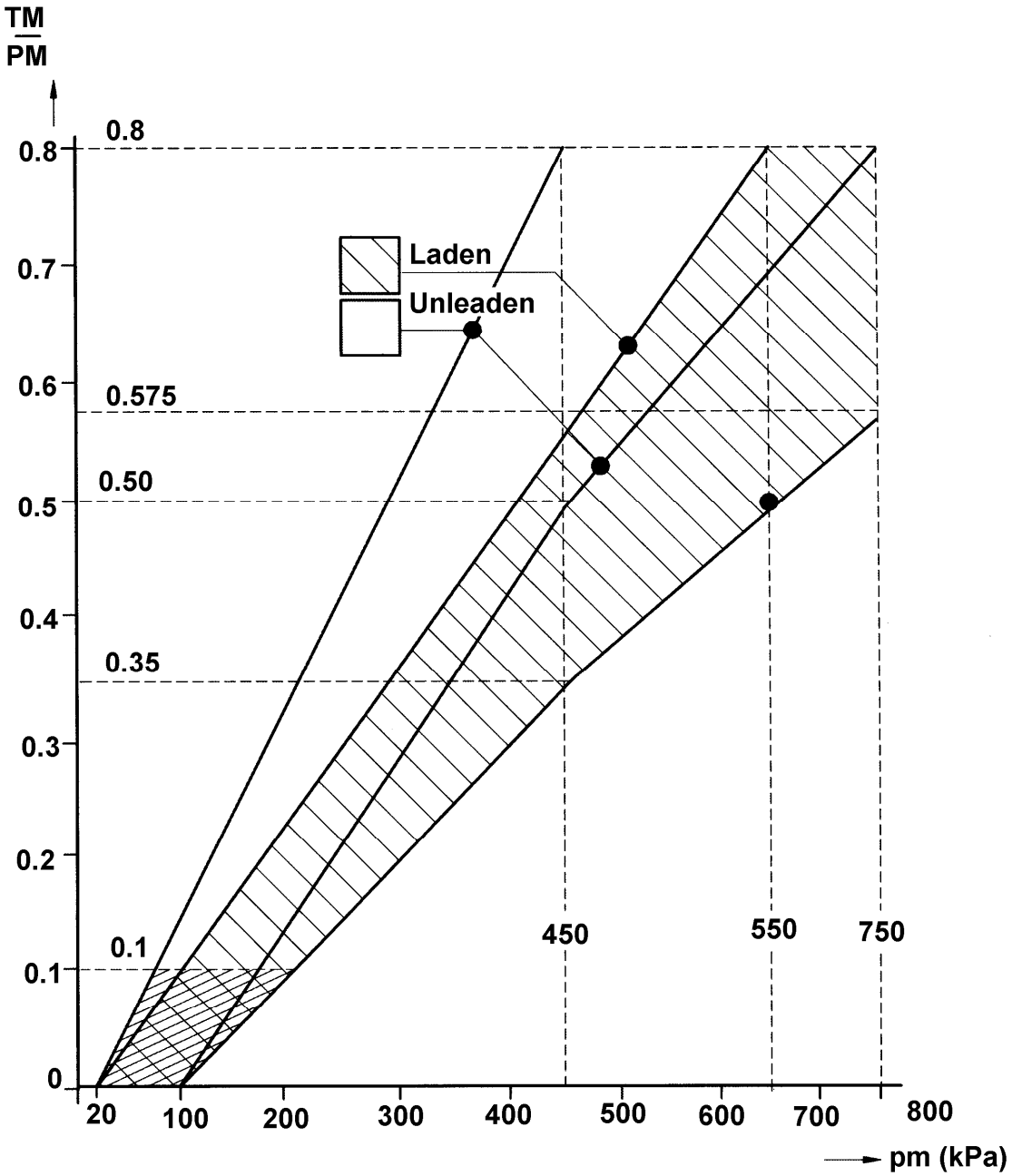


Figure 1B — Vehicles other than vehicles of category M_1 (see 4.1.1 and Table 2)



For braking ratios less than 0.1 the braking ratio need not be proportional to the coupling head pressure

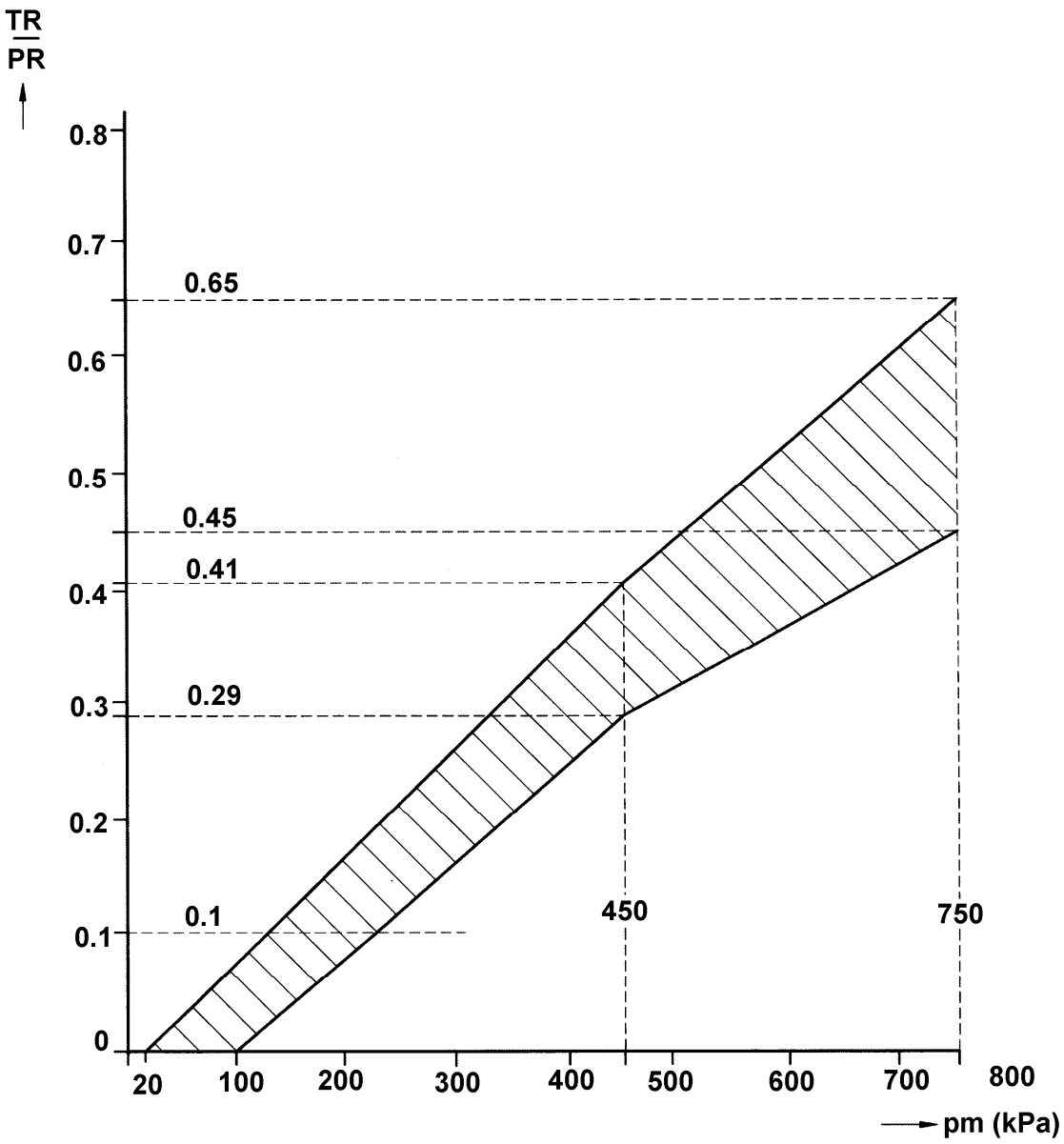
Figure 2 — Drawing vehicles and trailers (see 4.2.1)



a) For braking ratios less than 0.1 the braking ratio need not be proportional to the coupling head pressure

b) The relationship required by the diagram shall apply progressively for intermediate states of loading between the laden and unladen states and shall be achieved by automatic means.

Figure 3 — Drawing vehicles for semi-trailers (see 4.2.2)



a) For braking ratios less than 0.1 the braking ratio need not be proportional to the coupling head pressure

b) The relationship between the braking ratio $\frac{TR}{PR}$ and control line pressure for the laden and unladen condition is determined as follows:

The factors K_c (laden), K_v (unladen) are obtained by reference to Figure 4B.

Construct the laden and unladen bands by multiplying the upper and lower boundaries of the band in Figure 4A by the values obtained for K_c and K_v respectively.

Figure 4A — Semi-trailers (see 4.2.3)

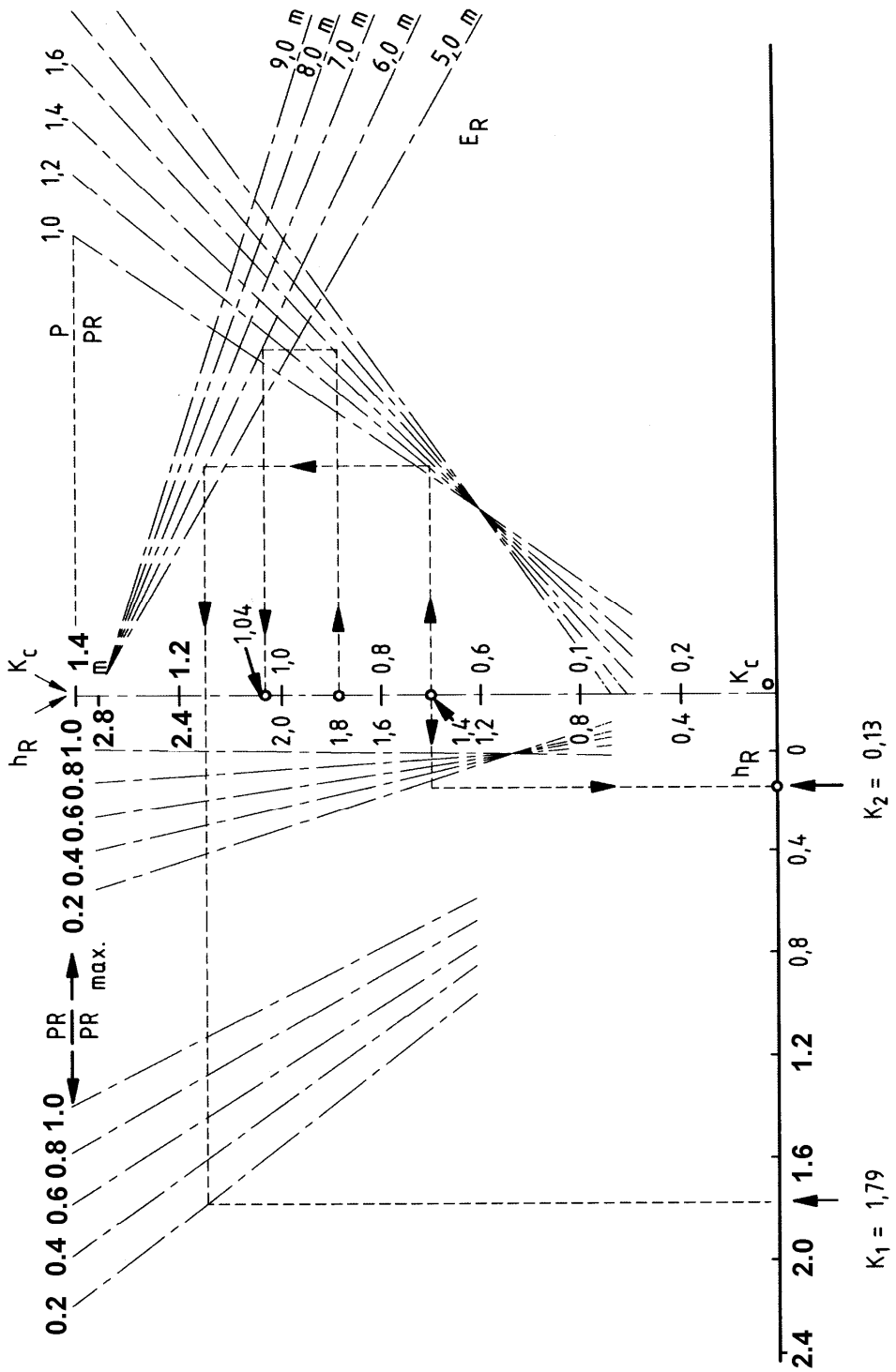


Figure 4B — Semi-trailers (see 4.2.3)

Annex A
(informative)

Explanation of the use of figure 4B

A.1 The formula from which figure 4B is derived is the following:

$$K = \left[1.7 - \frac{0.7PR}{PR_{max}}\right]\left[1.35 - \frac{0.96}{ER}\left(1.0 + (h_R - 1.2)\frac{P}{PR}\right)\right] - \left[1.0 - \frac{PR}{PR_{max}}\right]\left[\frac{hR - 1.0}{2.5}\right]$$

A.2 Example of the method of use

A.2.1 The broken lines shown on figure 4B refer to the determination of the factors K_c (laden) and K_v (unladen) for the following vehicle where:

	Laden	**unladen**
P	240 kN	42 kN
PR	150kN	30 kN
PR_{max}	150kN	150kN
h_R	1.8m	1.4m
E_R	6.0 m	6.0 m

In the rest of the example the figures in parenthesis relate only to the above vehicle.

A.2.2 Calculate the following ratios:

a) $\left[\frac{P}{PR}\right]$ laden (=1.6)

b) $\left[\frac{P}{PR}\right]$ unladen (=1.4)

c) $\left[\frac{P}{PR_{max}}\right]$ unladen (= 0.2)

A.2.3 Determination of the laden factor, k_c

a) Start at appropriate h_R (h_R = 1.8 m).

b) Move horizontally to the appropriate P/PR line (P/PR = 1.6).

c) Move vertically to appropriate E_R line (E_R = 6.0)m.

d) Move horizontally to k_c scale, k_c is the laden factor required (K_c = 1.04).

A.2.4 Determination of the unladen factor, K_v

A.2.4.1 Determination of the factor K_2

a) Start at appropriate h_R (h_R = 1.4 m).

b) Move horizontally to the appropriate $PR/PR_{max.}$ line in group of curves nearest to the vertical axis ($PR/PR_{max.}$ = 0.2).

c) Move vertically to horizontal axis and read off the value of K_2 (K_2 = 0.13 m).

A.2.4.2 Determination of factor K_i

a) Start at appropriate h_R (h_R = 1.4 m).

b) Move horizontally to the appropriate P/PR line (P/PR = 1.4).

c) Move vertically to the appropriate E_R line (E_R = 6.0 m).

d) Move horizontally to the appropriate PR/PR_{max} line in group of curves furthest from the vertical axis (PR/PR_{max}. = 0.2).

e) Move vertically to horizontal axis and read off the value of K_1 (K_1 = 1.79).

A.2.4.3 Determination of factor K_v

Obtain the unladen factor Kv from the following expression:

$K_V = K_1 - K_2$ (K_V =1.66).