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PROPOSAL FOR DRAFT AMENDMENTS TO REGULATION No. 13

(Braking)

Transmitted by the expert from the United Kingdom

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Note: This document is distributed to the Experts on Brakes and Running Gear only.

Annex 10

DISTRIBUTION OF BRAKING AMONG THE AXLES OF VEHICLES AND REQUIREMENTS FOR COMPATIBILITY BETWEEN TOWING VEHICLES AND TRAILERS

1. GENERAL REQUIREMENTS.

1.1. Vehicles of categories **M₂, M₃, N , O₃ and O₄** which are **not** equipped with an anti-lock system as defined in **Annex 13** to this Regulation shall meet all the requirements of this Annex. If a special device is used, this must operate automatically. However, vehicles in the above categories which are equipped with an anti-lock system as defined in **Annex 13**, shall also meet the requirements of paragraphs **7 and 8** of this Annex if they are in addition fitted with a special automatic device which controls the distribution of braking among the axles. In the event of failure of its control, it shall be possible to stop the vehicle as stipulated in paragraph **6**. of **this Annex**.

1.2. The requirements relating to the diagrams specified in paragraphs **3.1.5., 3.1.6., 4.1., 5.1. and 5.2.** of **this Annex**, are valid both for power-driven vehicles with a pneumatic control line according to paragraph **5.1.3.1.1**. of this Regulation and for power-driven vehicles with an **electric control line** according to paragraph **5.1.3.1.3**. of this Regulation. In both cases, the reference value (abscissa of the diagrams) will be the value of the transmitted pressure in the control line:

for vehicles equipped according to paragraph **5.1.3.1.1**. of this Regulation, this will be the actual pneumatic pressure in the control line (p_m) ;

for vehicles equipped according to paragraph **5.1.3.1.3**. of this Regulation, this will be the pressure corresponding to the transmitted digital demand value in the electric control line, according to **ISO 11992**:(**2003**).

Vehicles equipped according to paragraph **5.1.3.1.2**. of this Regulation (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.

1.3. In the case of vehicles of **category O** with pneumatic braking systems, when the alternative type approval procedure defined in **Annex 20** is utilised, the relevant calculations required in this Annex shall be made using the performance characteristics obtained from the relevant **Annex 19** verification reports and the centre of gravity height determined by the method defined in **Annex 20**, **Appendix 1**.

2. SYMBOLS.

i	=	axle index (i = 1, front axle; i = 2, second axle; etc.)
P_i	=	normal reaction of road surface on axle i under static conditions
N_i	=	normal reaction of road surface on axle i under braking
T_i	=	force exerted by the brakes on axle i under normal braking conditions on the road
f_i	=	T_i/N_i, adhesion utilized by axle i [1]
J	=	deceleration of vehicle
g	=	acceleration due to gravity: g = 10 m/s²
z	=	braking rate of vehicle = J/g [2]
P	=	mass of vehicle
h	=	height above ground of centre of gravity (specified by the manufacturer and agreed by the Technical Services conducting the approval test)
E	=	wheelbase

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[1] "**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] For semi-trailers, z is the braking force divided by the static load on the semi-trailer axle(s).

k	=	theoretical coefficient of adhesion between tyre and road
K_c	=	correction factor: semi-trailer laden

K_v = correction factor: semi-trailer unladen

T_M = sum of braking forces at the periphery of all wheels of towing vehicles for trailers

P_M = total normal static reaction of road surface on wheels of towing vehicles for trailers [3]

p_m = pressure at coupling head of control line

T_R = sum of braking forces at periphery of all wheels of trailer

P_R = total normal static reaction of road surface on all wheels of trailer [4]

$P_{R\,max}$ = value of P_R at maximum mass of trailer

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

h_R = height above ground of centre of gravity of semi-trailer specified by the manufacturer and agreed by the Technical Services conducting the approval test

3. REQUIREMENTS FOR POWER-DRIVEN VEHICLES.

3.1. Two-axled vehicles

3.1.1. For all categories of vehicles for **k** values between **0.2 and 0.8**:[5]

$$z \ \geq \ 0.1 + 0.85\,(\,k\,\text{-}\,0.2\,)$$

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. As from **October 1, 1990,** at all **braking rates** between **0.15 and 0.8,** for vehicles of category **N₁**. with a laden/unladen rear axle loading ratio not exceeding **1.5** or having a maximum mass of less than **2 tonnes,** in the range of **z values** between **0.3** and **0.45**, an inversion of the adhesion utilization curves is permitted provided that the adhesion utilization curve of the rear axle does not exceed by more than **0.05** the line defined by the formula **k = z** (line of ideal adhesion utilization - see **diagram 1A** of this Annex);

3.1.2.2. for all **braking rates** between **0.15** and **0.50** in the case of other vehicles of category **N₁**

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 equations **k = z ± 0.08** as shown in **diagram 1C** of this Annex, where the adhesion utilization curve for the rear axle may cross the line **k = z - 0.08**; and complies for a braking rate between **0.30 and 0.50**, with the relation $z \geq$ **k - 0.08**; and between **0.50 and 0.61** with the relation **z ≥ 0.5k + 0.21**.

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[3]   As referred to in paragraph **1.4.4.3**. of **Annex 4** to this Regulation.

[4]   As referred to in paragraph **1.4.4.2**. of **Annex 4** to this Regulation.

[5]   The provisions of paragraph **3.1.1**. do **not** affect the requirements of **Annex 4** to this Regulation relating to the braking performance. However, if, in tests made under the provisions of paragraph **3.1.1.**, braking performances are obtained which are higher than those prescribed in **Annex 4**, the provisions relating to the adhesion utilization curves shall be applied within the areas of **diagrams 1A, 1B and 1C** of this Annex defined by the straight lines **k = 0.8 and z = 0.8.**

3.1.2.3.   for all **braking rates** between **0.15 and 0.30** in the case of vehicles of other categories; 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 equations **k = z ± 0.08** as shown in **diagram 1B** of this Annex and the adhesion utilization curve for the rear axle

for braking ratios **z ≥ 0.3** complies with the relation **z ≥ 0.3 + 0.74 (k - 0.38).**

3.1.3.   In the case of a **power-driven** vehicle authorized to tow trailers of category **O₃ or O₄** 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 shall be between **6.5 and 8.5 bar** 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 of the service braking system shall provide a digital demand value corresponding to a pressure between **6.5 and 8.5 bar** (see **ISO 11992**:(**2003**)).

3.1.3.3.   These values shall be demonstrably present in the power-driven vehicle when uncoupled from the trailer. The compatibility bands in the diagrams specified in paragraphs **3.1.5., 3.1.6., 4.1., 5.1. and 5.2**. of this Annex, should **not** be extended beyond **7.5** bar and/or the corresponding digital demand value (see **ISO 11992**:(**2003**)

3.1.3.4.   It must be ensured that, at the coupling head of the supply line, a pressure of at least **7 bar** is available when the system is at cut-in pressure. This pressure shall be demonstrated without applying the service brakes.

3.1.4.   **Verification of the requirements of paragraphs 3.1.1. and 3.1.2.**.

3.1.4.1. In order to verify the requirements of paragraphs **3.1.1. and 3.1.2**. of this Annex, the manufacturer shall provide the adhesion utilization curves for the front$_1$ and rear$_2$ axles calculated by the formulae:

$$f_1 = \frac{T_1}{N_1} = \frac{T_1}{P_1 + z \cdot \dfrac{h}{E} \cdot P \cdot g}$$

$$f_2 = \frac{T_2}{N_2} = \frac{T_2}{P_2 - z \cdot \dfrac{h}{E} \cdot P \cdot g}$$

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

3.1.4.1.1.   **unladen**, in running order with the driver on board; in the case of a vehicle presented as a bare chassis-cab, a supplementary load may be added to simulate the mass of the body, **not** exceeding the **minimum mass** declared by the manufacturer in **Annex 2** to this Regulation,

3.1.4.1.2.   **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,

3.1.4.2.   If it is not possible, for vehicles with (**permanent) all-wheel drive**, to carry out the mathematical verification pursuant to paragraph **3.1.4.1.,** 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.

3.1.4.3.   **Procedure to verify the requirements of paragraph 3.1.4.2.**.

3.1.4.3.1. 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 paragraph **3.1.4.3.2.**.

3.1.4.3.2. **Test speeds**:
60 km/h, but **not** exceeding **0.8 v_max** for decelerations on low coefficient of

$$h = \frac{h_o \cdot P_O + h_s \cdot P_s}{P}$$

friction road surfaces;
80 km/h, but **not** exceeding **v_max** for decelerations on high coefficient of friction road surfaces.

3.1.4.3.3. The pedal force applied **may exceed** the permissible actuation forces pursuant to **Annex 4**, paragraph **2.1.1.**.

3.1.4.3.4. Pedal force is applied and increased such that the **second** wheel on the vehicle will 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).

3.1.4.4. The tests prescribed in paragraph **3.1.4.2.** 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.

3.1.4.5. For vehicles fitted with an electric regenerative braking system of **category B**, where the electric regenerative braking capacity is influenced by the electric state of charge, the curves shall be plotted by taking account of the electric regenerative braking component under the **minimum and maximum** conditions of delivered braking force. This requirement is not applicable if the vehicle is equipped with an antilock device which controls the wheels connected to the electric regenerative braking and shall be replaced by the requirements of **Annex 13**.

3.1.5. **Towing vehicles other than tractors for semi-trailers**.

3.1.5.1. In the case of a power-driven vehicle authorized to tow trailers of category **O_3 or O_4** fitted with a compressed-air braking system, the permissible relationship between the braking rate **T_M/P_M** and the pressure **p_m** shall lie within the areas shown on **diagram 2** of this Annex for all pressures between **0.2 and 7.5 bar.**

3.1.6. **Tractors for semi-trailers**

3.1.6.1. **Tractors with unladen semi-trailer**. An unladen combination is understood to be a tractor in running order, with the driver on board, coupled to an unladen semi-trailer. The dynamic load of the semi-trailer on the tractor shall be represented by a static mass (P_s) mounted at the fifth wheel coupling equal to **15%** of the maximum mass on the coupling. The braking forces must continue to be regulated between the state of the "tractor with unladen semi-trailer" and that of the "tractor alone"; the braking forces

$$P_s = P_{so}(1 + 0.45z)$$

relating to the "tractor alone" shall be verified.

3.1.6.2. **Tractors with laden semi-trailer**. A laden combination is understood to be a tractor in running order, with the driver on board, coupled to a laden semi-trailer. The dynamic load of the semi-trailer on the tractor shall be represented by a **static mass P_s** mounted at the fifth wheel coupling equal to:
where: P_{so} represents the difference between the maximum laden mass of the tractor and its unladen mass.

For h the following value shall be taken:
where: h_o is the height of the centre of gravity of the tractor
h_s is the height of the coupling on which the semi-trailer rests

P$_o$ is the unladen mass of the tractor alone

$$P = P_o + P_s = (P_1 + P_2)/g$$

3.1.6.3. In the case of a vehicle fitted with a compressed-air braking system, the permissible relationship between the braking rate **T$_M$/P$_M$** and the pressure **p$_m$** shall be within the areas shown on **diagram 3** of this Annex for all pressures between **0.2 and 7.5 bar.**

3.2. Vehicles with more than two axles.

The requirements of paragraph **3.1.** of this Annex shall apply to vehicles with more than **two** axles. The requirements of paragraph **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 SEMI-TRAILERS.

4.1.   For semi-trailers fitted with compressed-air braking systems:

4.1.1.   The permissible relationship between the braking rate **T$_R$/P$_R$** and the pressure **p$_m$** shall lie within two areas derived from **diagrams 4A and 4B** for all pressures between **0.2 and 7.5** bar, in both the laden and unladen states of load. This requirement shall be met for all permissible load conditions of the semi-trailer axles.

4.1.2.   If the requirements of paragraph **4.1.1.** of this Annex cannot be satisfied in conjunction with the requirements of paragraph **3.1.2.1.** of **Annex 4** to this Regulation for semi-trailers with a Kc factor less than **0.8**, then the semi-trailer must meet the minimum braking performance specified in paragraph **3.1.2.1.** of **Annex 4** to this Regulation and be fitted with an **anti-lock system** complying with **Annex 13** to this Regulation, except the compatibility requirement in **paragraph 1**. of that Annex.

5.   REQUIREMENTS FOR FULL AND CENTRE-AXLE TRAILERS.

5.1.   For full trailers fitted with compressed-air braking systems:

5.1.1. The requirements set out in paragraph **3.1.** of this Annex shall apply to **twin-axle** trailers (except where the axle spread is less than **2 metres**).

5.1.2. **Full trailers** with **more than two axles** shall be subject to the requirements of paragraph **3.2.** of this Annex.

5.1.3. The permissible relationship between the braking rate **T$_R$/P$_R$** and the pressure **p$_m$** shall lie within the designated areas in **diagram 2** of this Annex for all pressures between **0.2 and 7.5** bar, in both the laden and unladen states of load.

5.2.   For centre-axle trailers fitted with compressed-air braking systems:

5.2.1. The permissible relationship between the braking rate **T$_R$/P$_R$** and the pressure **p$_m$** shall lie within two areas derived from **diagram 2** of this Annex, by multiplying the vertical scale by **0.95** . This requirement shall be met at all pressures between **0.2 and 7.5** bar, in both the laden and unladen states of load.

5.2.2. If the requirements of paragraph **3.1.2.1.** of **Annex 4** to this Regulation cannot be satisfied due to lack of adhesion, then the centre-axle trailer must be fitted with an **anti-lock** system complying with **Annex 13** to this Regulation.

6. REQUIREMENTS TO BE MET IN CASE OF FAILURE OF THE BRAKING DISTRIBUTION SYSTEM.

When the requirements of this Annex 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 power-driven vehicles;
For those power-driven vehicles authorized to tow a trailer fitted with compressed-air braking systems, it must be possible to achieve a pressure at the coupling head of the control line within the range specified in paragraph **3.1.3**. of this Annex.
In the event of **failure of the control** of the device on trailers, a service braking performance of at least **30%** of that **prescribed** for the vehicle in question shall be attained.
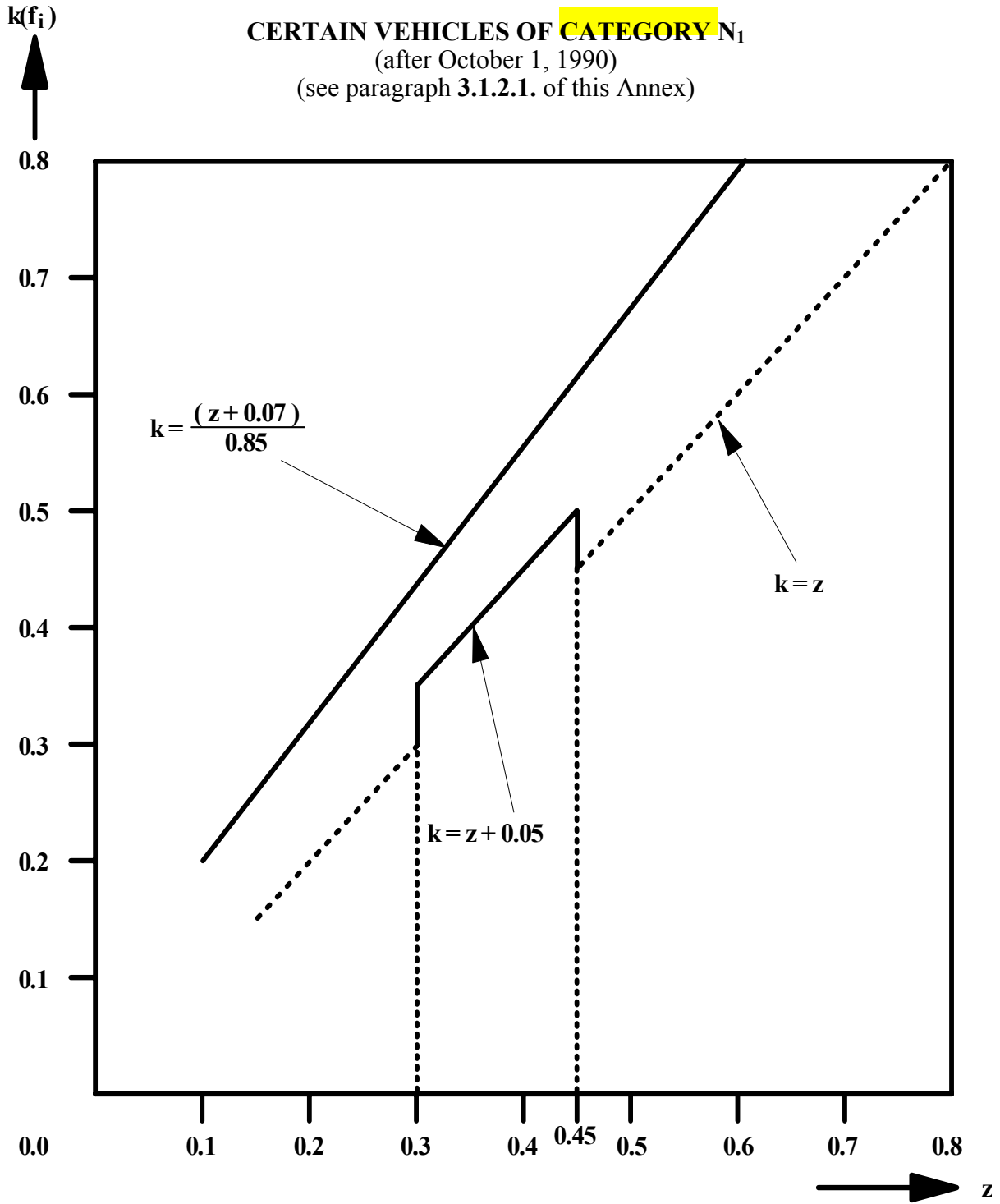
7. MARKINGS.

7.1. Vehicles which meet the requirements of this Annex by means of a device mechanically controlled by the suspension of the vehicle, shall be marked 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.

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

7.2. When the requirements of this Annex are met by means of a device which modulates the **air** pressure in the brake transmission, the vehicle must 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%** of the maximum design inlet pressure, as declared by the vehicle manufacturer, for the following states of load:

7.2.1. technically permissible maximum axle load for the axle(s) which control(s) the device;

7.2.2. axle load(s) corresponding to the unladen mass of the vehicle in running order as stated in paragraph **13. of Annex 2** to this Regulation;

7.2.3. the axle load(s) approximating to the vehicle with proposed bodywork in running order where the axle load(s) mentioned in paragraph **7.2.2.** of this Annex relate(s) to the vehicle chassis with cab;

7.2.4. 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 paragraphs **7.2.1. , 7.2.2. and 7.2.3.** of this Annex.

7.3. Paragraph **14.7. of Annex 2** to this Regulation must include information to enable compliance with the requirements of paragraphs **7.1. and 7.2.** of this Annex to be checked.

7.4. The markings referred to in paragraphs **7.1. and 7.2**. of this Annex must 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 braking is shown in **diagram 5** of this Annex.

7.5. **Electronically controlled brake force distribution systems** that cannot fulfil the requirements of paragraphs **7.1., 7.2., 7.3. and 7.4.** above, shall have a self checking procedure of the functions which influence brake force distribution.

8. VEHICLE TESTING.

During the type-approval testing of a vehicle, the technical inspection authority shall verify conformity with the requirements contained in the present Annex and carry out any further tests considered necessary to this end. The report on the additional tests shall be appended to the Type-Approval form.
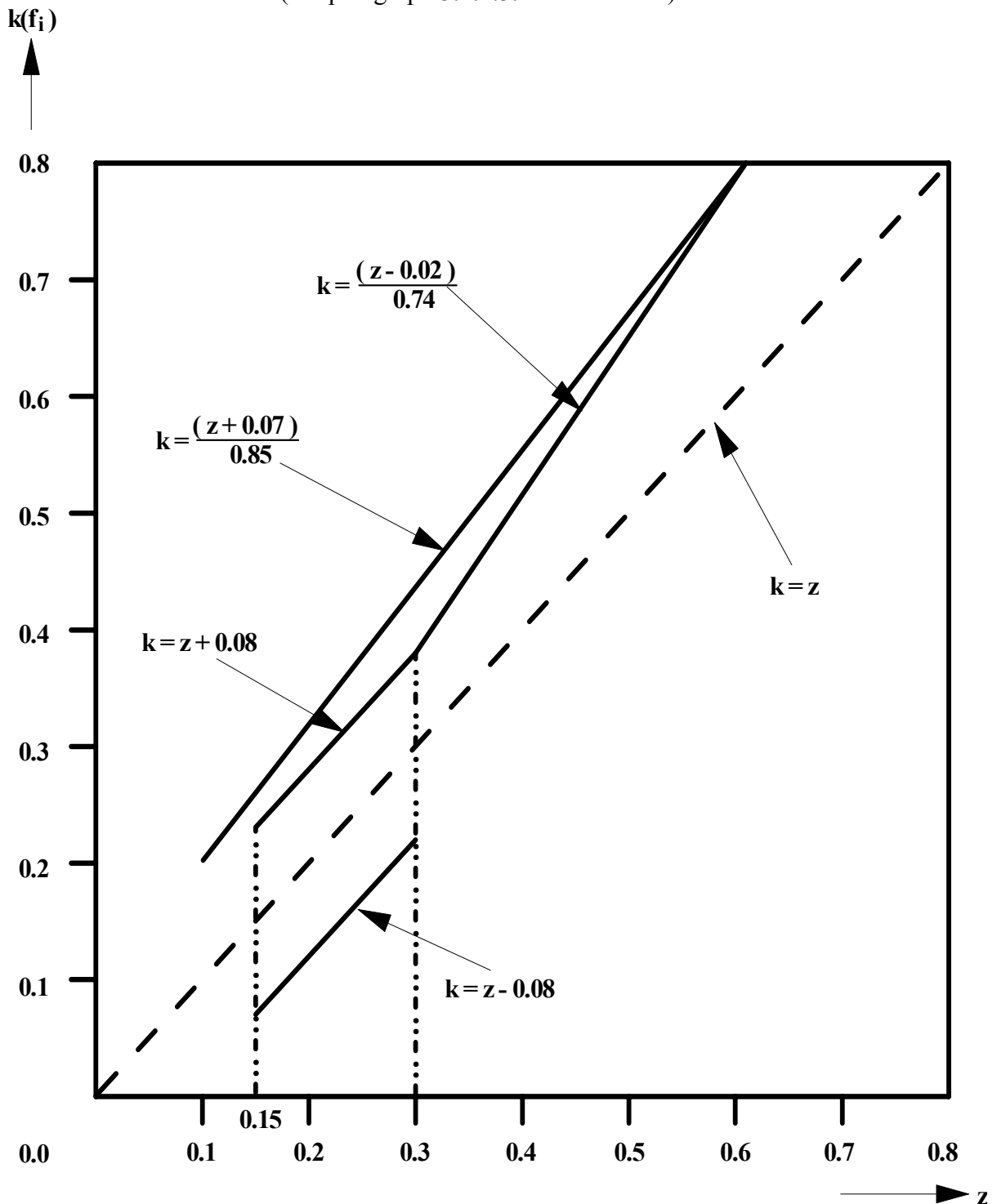
DIAGRAM 1A

CERTAIN VEHICLES OF CATEGORY N$_1$
(after October 1, 1990)
(see paragraph **3.1.2.1.** of this Annex)

k(f$_i$)

$$k = \frac{(z + 0.07)}{0.85}$$

k = z

k = z + 0.05

0.8

0.7

0.6

0.5

0.4

0.3

0.2

0.1

0.0   0.1   0.2   0.3   0.4   0.45   0.5   0.6   0.7   0.8

z

DIAGRAM 1B

POWER-DRIVEN VEHICLES OTHER THAN THOSE OF CATEGORY N_1
(see paragraph **3.1.2.3.** of this Annex)

$k(f_i)$

$k = \dfrac{(z - 0.02)}{0.74}$

$k = \dfrac{(z + 0.07)}{0.85}$

$k = z$

$k = z + 0.08$

$k = z - 0.08$

0.8

0.7

0.6

0.5

0.4

0.3

0.2

0.1

0.15

0.0   0.1   0.2   0.3   0.4   0.5   0.6   0.7   0.8 z

Note: The lower limit **$k = z - 0.08$** is not applicable for the adhesion utilization of the rear axle.
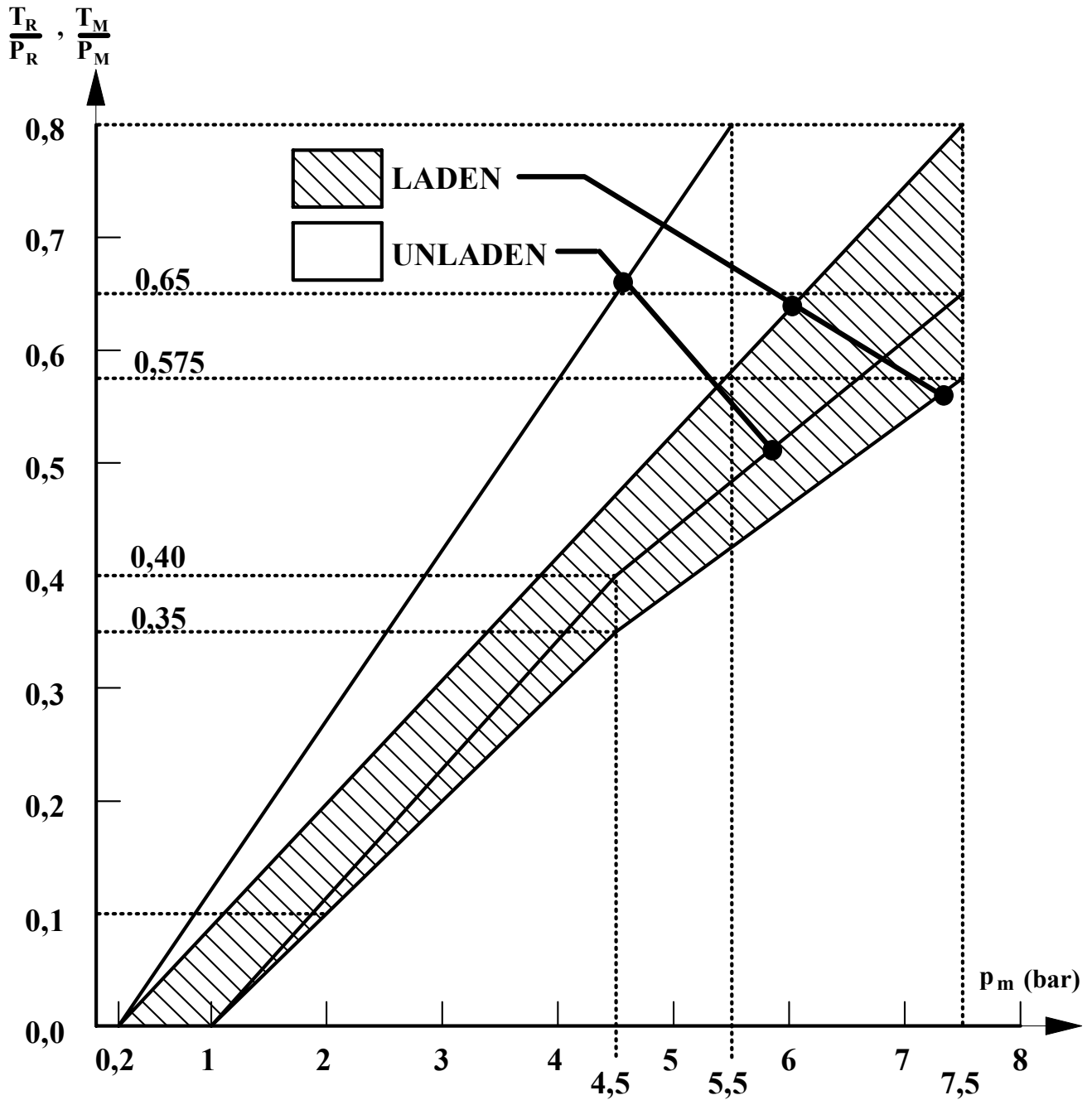
DIAGRAM 1C

VEHICLES OF CATEGORY N₁
(with certain exceptions after October 1, 1990)
(see paragraph **3.1.2.2.** of this Annex)
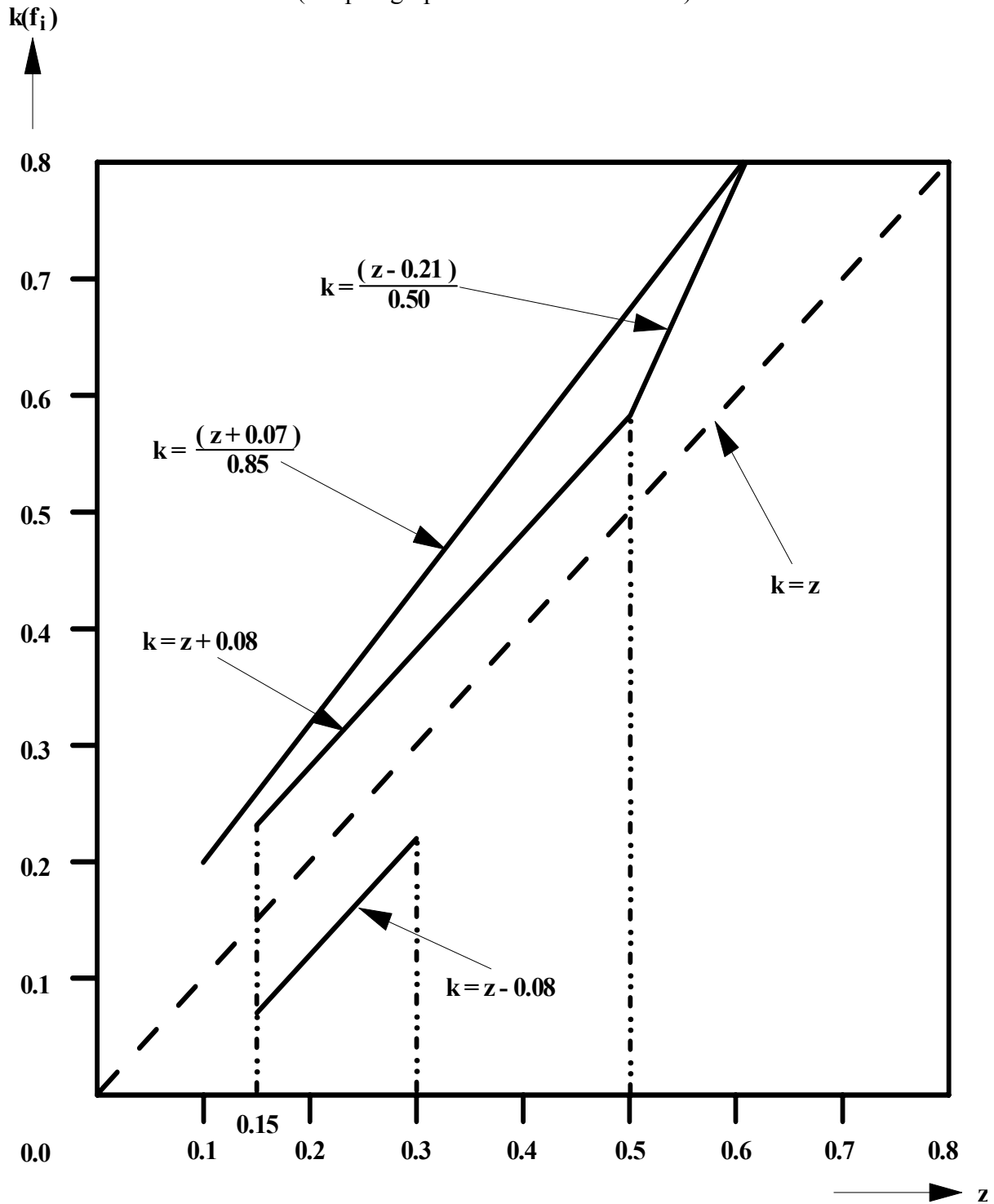
Note: The lower limit **k = z - 0.08** is not applicable for the adhesion utilization of the rear axle.
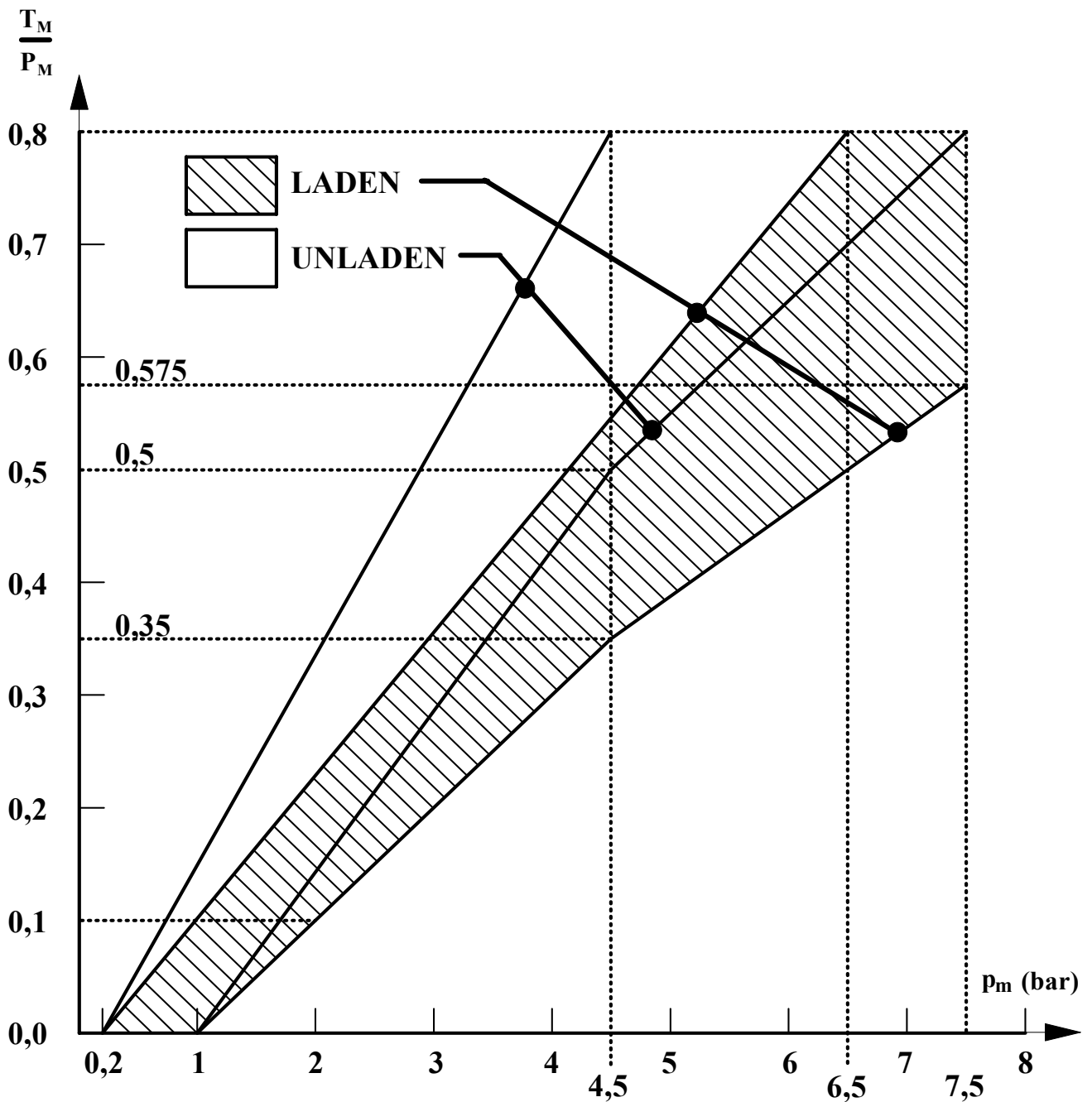
DIAGRAM 2

TOWING VEHICLES AND TRAILERS (except tractors for semi-trailers and semi-trailers)
(see paragraphs **3.1.5.1.** of this Annex)

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

DIAGRAM 3

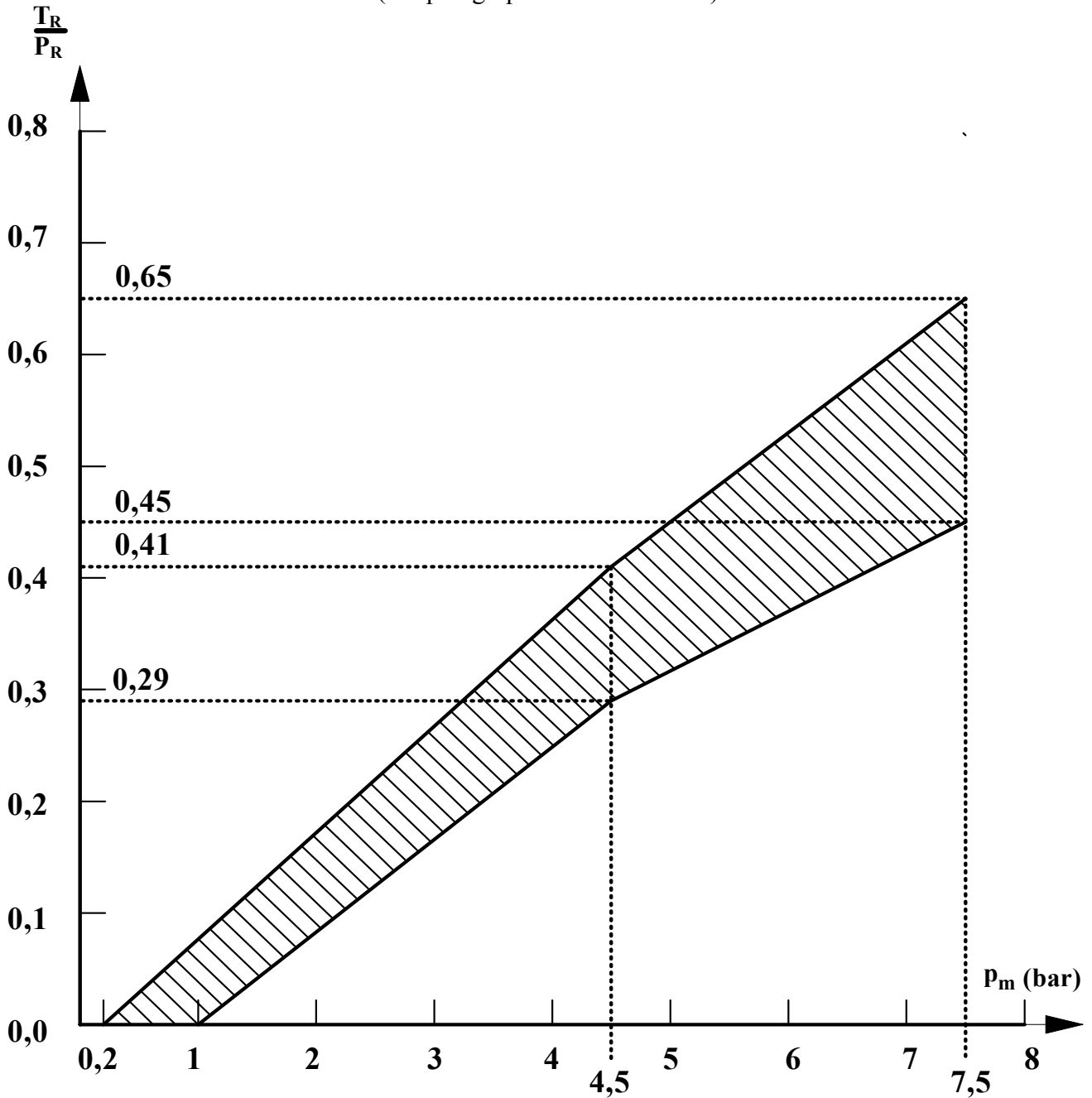### TRACTORS FOR SEMI-TRAILERS (see paragraph **3.1.6.** of this Annex)

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

DIAGRAM 4A

SEMI-TRAILERS
(see paragraph **4.** of this Annex)

(1) The relation between the braking rate T_R / P_R and the control line pressure for the laden and unladen conditions is determined as follows:

The factors K_c (laden), K_v (unladen) are obtained by reference to diagram 4B. To determine the areas corresponding to the laden and unladen conditions, the values of the ordinates of the upper and lower limits of the hatched area in diagram 4A are multiplied by the factors K_c and K_v respectively.

DIAGRAM 4B

(see paragraph **4.** and diagram 4A of this Annex)

EXPLANATORY NOTE ON THE USE OF DIAGRAM 4B

1.   Formula from which diagram 4B is derived:

$$K = (1.7 - \frac{0.7 P_R}{P_{Rmax}})(1.35 - \frac{0.96}{E_R}(1.0 + (h_R - 1.2)\frac{g.P}{P_R})) - (1.0 - \frac{P_R}{P_{Rmax}})(\frac{h_R - 1.0}{2.5})$$

2.   Description of method of use with practical example.

2.1.   The broken lines shown on diagram 4B refer to the determination of the factors K_c and K_v for the following vehicle, where:

	Laden	Unladen
P	24 tonnes	4.2 tonnes
P_R	150kN	30kN
P_{Rmax}	150kN	150kN
h_R	1.8m	1.4m
E_R	6.0m	6.0m

If P and P_R are both in tonnes or both are in kg, g is not required in the above formula or in the ratios in 2.2. below.

In the following paragraphs the figures in parentheses relate only to the vehicle being used for the purpose of illustrating the method of using diagram 4 B.

2.2.   Calculation of ratios

$$(a)\,(\frac{g.P}{P_r})\ \text{laden}\ \ (=1.6)$$

$$(b)\,(\frac{g.P}{P_r})\ \text{unladen}\ (=1.4)$$

$$(c)\,(\frac{P_R}{P_{Rmax}})\ \text{unladen}\ (=0.2)$$

2.3.   Determination of the correction factor when laden, K_c:

   (a)   Start at the appropriate value of h_R (h_R=1.8 m)

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

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

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

2.4.   Determination of the correction factor when unladen, K_v:

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 P_R/P_{Rmax} line in the group of curves nearest to vertical axis.   (P_R/P_{Rmax}= 0.2)

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

2.4.2.   Determination of the factor K_1:

(a)   Start at the appropriate value of h_R. (h_R = 1.4 m)

(b)   Move horizontally to the appropriate $g.P/P_R$ line.   ($g.P/P_R$ = 1.4)

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

(d)   Move horizontally to the appropriate P_R/P_{Rmax} line in the group of curves furthest from the vertical axis. (P_R/P_{Rmax} = 0.2)

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

2.4.3.   Determination of the factor K_v:

The unladen correction factor K_v is obtained from the following expression:

$$K_v = K_1 - K_2 \quad (Kv = 1.66)$$

DIAGRAM 5

BRAKE LOAD SENSING DEVICE
(see paragraph **7.4.** of this Annex)

Control data	Vehicle Loading	Axle No. 2 - load at the ground (kN)	Inlet pressure (bar)	Nominal Outlet Pressure (bar)
F = 100mm L = 150mm	Laden	100	6	6
	Unladen	15	6	2.4

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