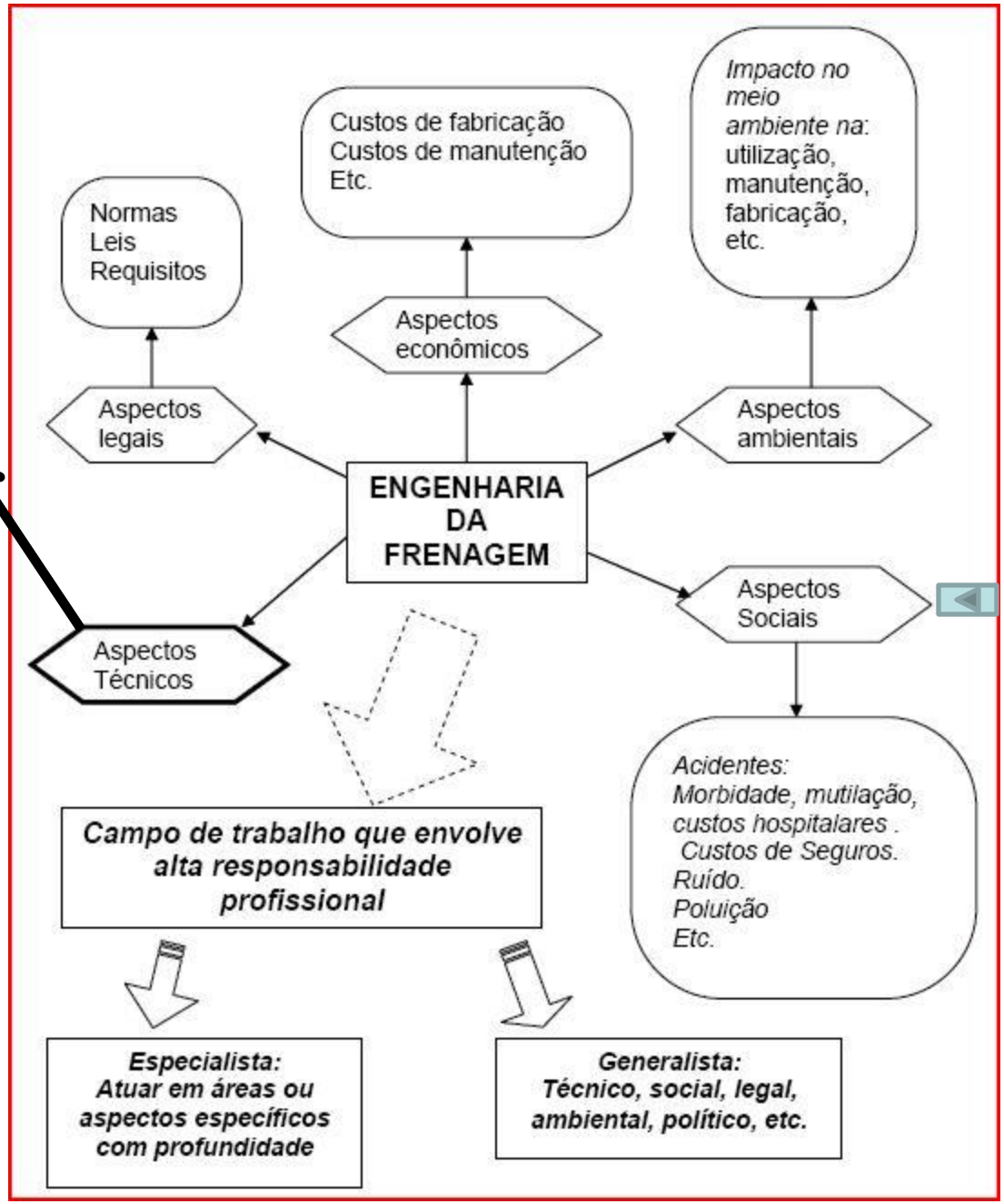
FREIO X SEGURANÇA

EVITAR O ESCORREGAMENTO DAS RODAS

QUASE SEMPRE O FREIO ESTÁ ENVOLVIDO NO ACIDENTE

QUE PARADA EFICIENTE



ECE REGULATION No.13 & EEC DIRECTIVE 71/320

SUMMARY OF BRAKE PERFORMANCE TESTS & REQUIREMENTS

		CARS & BUSES			VANS & TRUCKS			TRAILERS			
NOTATION:	Vehicle Category	M1	M2	M3	N1	N2	N3	O1	O2	O3	O4
	No. of Passenger Seats (excl.driver)	≤8	>8	>8					NBR 10966		
FL = Fully laden UL = Unladen	Max. Vehicle Weight (Tonnes)		≤5	>5	≤3½	3½–12	>12	≤¾	¾–3½	3½–10	>10
SERVICE BRAKE (SB)	Acting on all wheels, properly distributed and symmetric across vehicle. Braking distribution in accordance with Annex 10 and 75/524, respectively.										
1. TYPE - 0 TEST in Neutral. NBR 10967	Prescribed Speed km/h	80	60	60	80	60	60	Service Brake is Optional	60		
Cold brakes FL & UL	Stopping Distance m ≤	0.1V + V^2/150	0.15V+V^2/130						Brake Force ≥ 50% of Trailer max. axle wt. (45% for semi-trailers) using ≤ 6.5 bar		
	MFDD m/sec² ≥	5.8	5.0								
	Pedal Effort daN ≤	50	70						Overrun Brakes permitted for 01/02 only		
2. TYPE - 0 TEST in Gear. Cold brakes FL & UL	Effectiveness tests from various speeds (30% to 80% of Vmax) - check vehicle behaviour.										
3. TYPE - 0 TEST in Gear.	Prescribed Speed = 80% Vmax, but km/h ≤	160	100	90	120	100	90				
Cold brakes FL & UL	Stopping Distance m ≤	0.1V + V^2/130	0.15V+V^2/103.5								
	MFDD m/sec² ≥	5.0	4.0								
	Pedal Effort daN ≤	50	70								

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SUMMARY OF BRAKE PERFORMANCE TESTS & REQUIREMENTS

		CARS & BUSES			VANS & TRUCKS			TRAILERS			
NOTATION:	Vehicle Category	M1	M2	M3	N1	N2	N3	O1	O2	O3	O4
	No. of Passenger Seats (excl.driver)	≤8	>8	>8							
FL = Fully laden UL = Unladen	Max. Vehicle Weight (Tonnes)		≤5	>5	≤3½	3½–12	>12	≤¾	¾–3½	3½–10	>10
SERVICE BRAKE (SB)	Acting on all wheels, properly distributed and symmetric across vehicle. Braking distribution in accordance with Annex 10 and 75/524, respectively.										
4. TYPE - I TEST by repeated braking.											
NBR 10967	V1 = 80% Vmax , but km/h ≤	120	100	60	120	60	60				
	V2 = 1/2 V1										
In gear :	Time Interval secs	45	55	60	55	60	60				
FL	No. of Cycles	15	15	20	15	20	20				
N.B. First snub at 3.0 m/sec² deceleration; remaining snubs at same Pedal Effort.											
5. TYPE - I TEST by continuous braking.											
FL											Drag test at 40 km/h for 1.7 km on 7% slope
6. HOT EFFECTIVENESS after Type-I Tests											
Hot brakes FL	Prescribed Speed and Pedal Effort - as Test 1 :										40 km/h Brake Force ≥ 36% of Trailer max.axle wt. and ≥ 60% of Test 1 achievement
	Performance to be ≥ 80% of Test 1 requirement and ≥ 60% of Test 1 achievement.										

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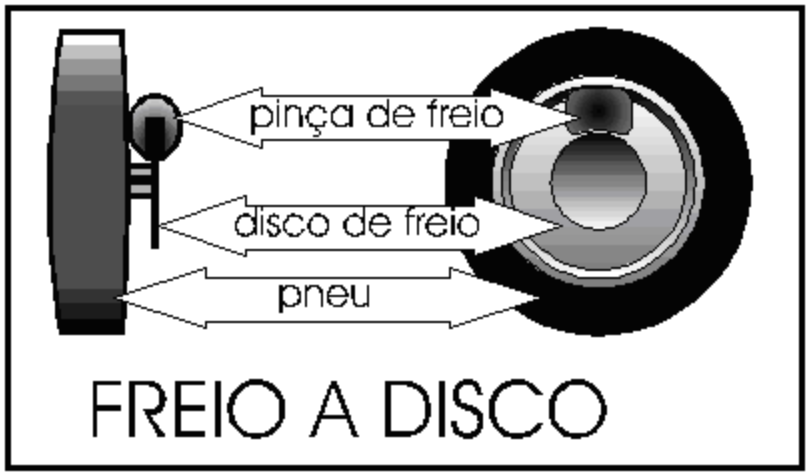
SUMMARY OF BRAKE PERFORMANCE TESTS & REQUIREMENTS

		CARS & BUSES			VANS & TRUCKS			TRAILERS			
NOTATION:	Vehicle Category	M1	M2	M3	N1	N2	N3	O1	O2	O3	O4
	No. of Passenger Seats (excl.driver)	≤8	>8	>8							
FL = Fully laden UL = Unladen	Max. Vehicle Weight (Tonnes)		≤5	>5	≤3½	3½–12	>12	≤¾	¾–3½	3½–10	>10
SERVICE BRAKE (SB)	Acting on all wheels, properly distributed and symmetric across vehicle. Braking distribution in accordance with Annex 10 and 75/524, respectively.										
7. TYPE - II TEST for long descents NBR 10967											
In gear FL	For M3 N3 O4 vehicles only	Drag test at 30 kp/h for 6 km on 6% slope (or 0.5 m/sec^2 by engine alone)									
7A. TYPE - IIA (BIS) TEST for 'Retarders'											
In gear FL	For M3 vehicles (instead of Test 7) - except 'urban buses'	Drag test at 30 kp/h for 6 km on 7% slope (or 0.6 m/sec^2 by engine alone) - without using Service, Emergency or Parking Brake									
8. HOT EFFECTIVENESS after Type-II Tests											
Hot brakes FL	Prescribed Speed and Pedal Effort - as Test 1 :										
	Stopping Distance m ≤		60 km/h			60 km/h					40 km/h
	MFDD m/sec^2 ≥		0.15V + 1.33V^2/130	3.75		0.15V + 1.33V^2/115	3.3				≥ 33% of Trailer max. axle wt.

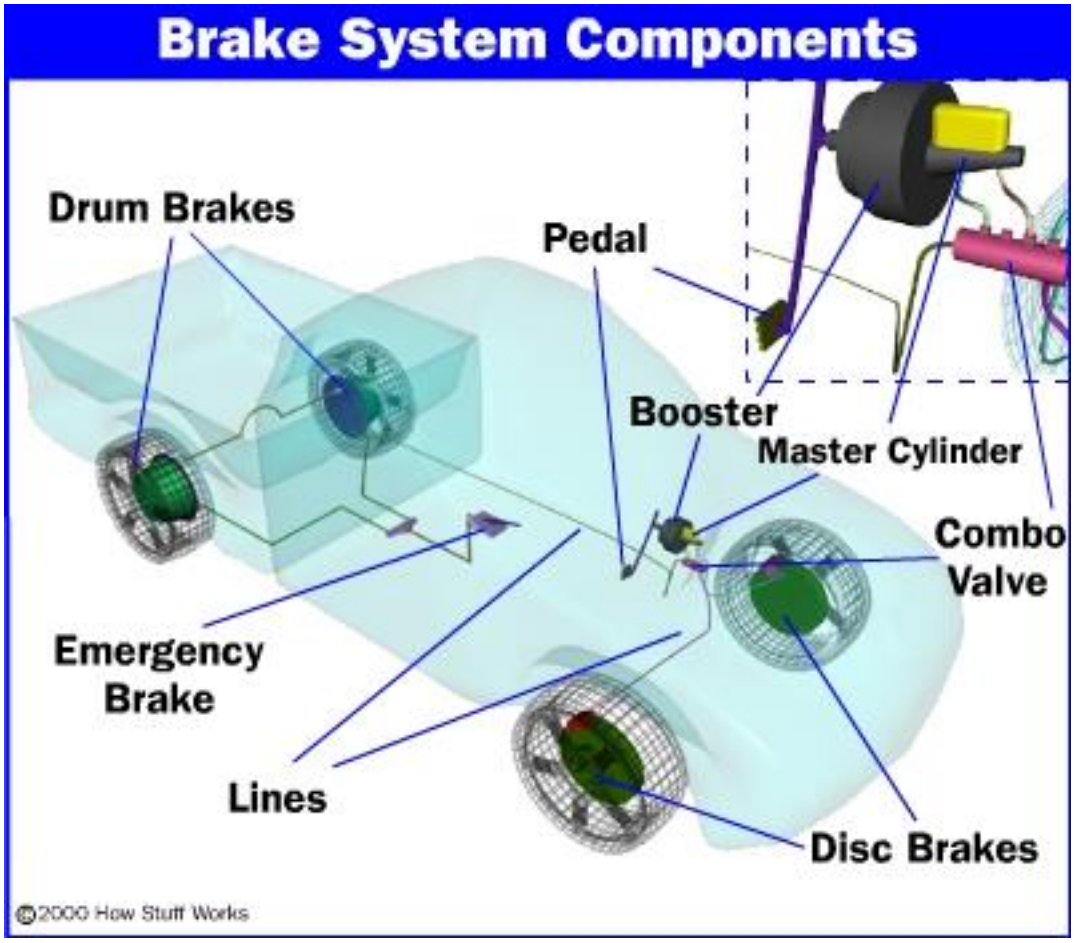
Freios mais comuns



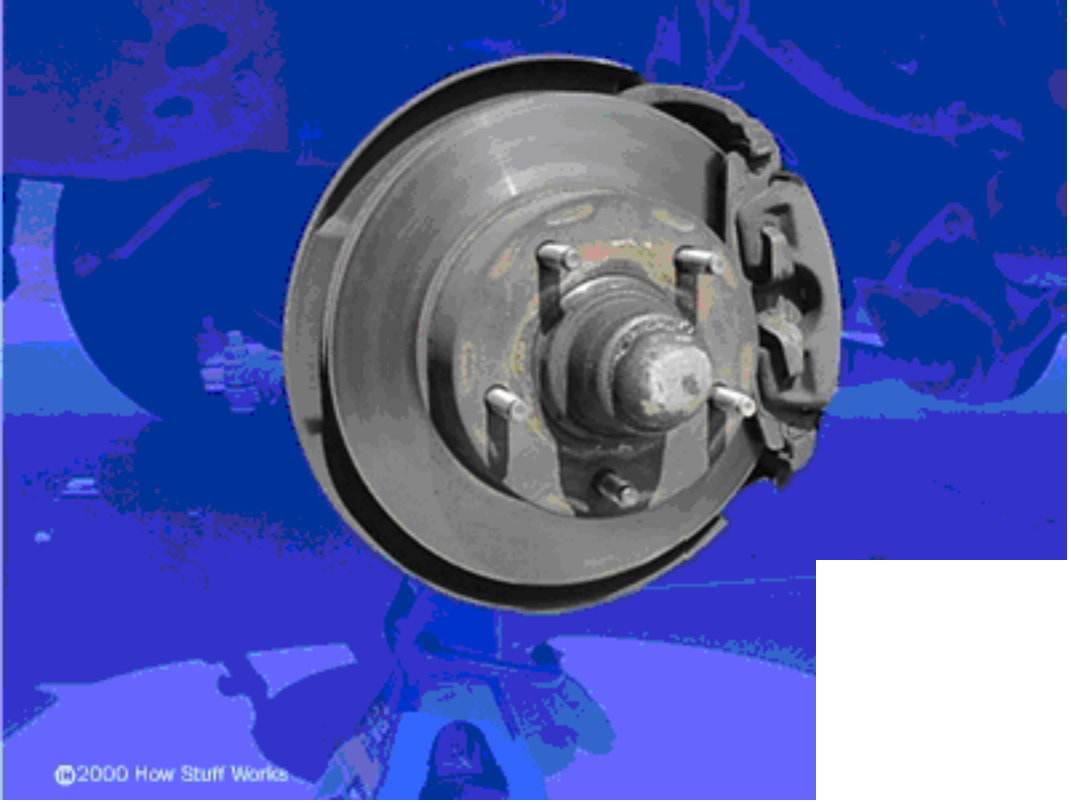
HIDRÁULICOS

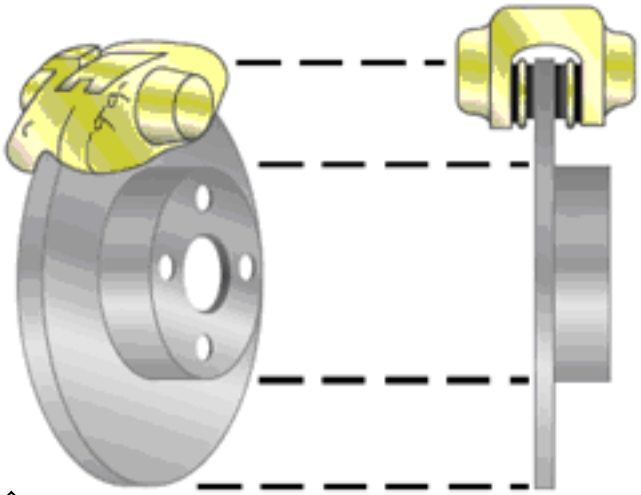
PNEUMÁTICOS

Componentes do sistema de freios

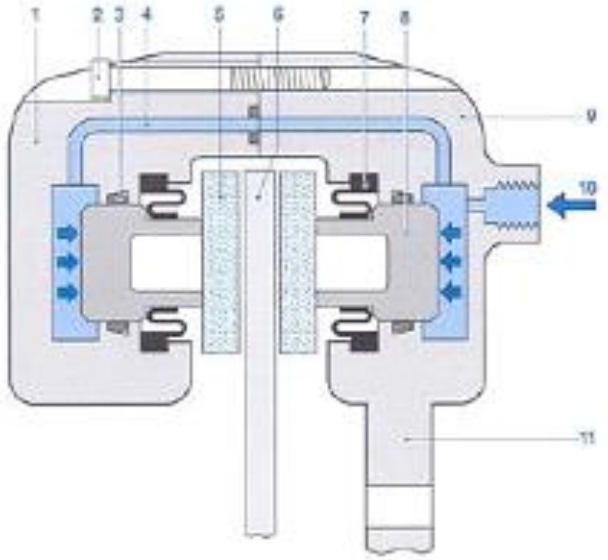


Freio a disco



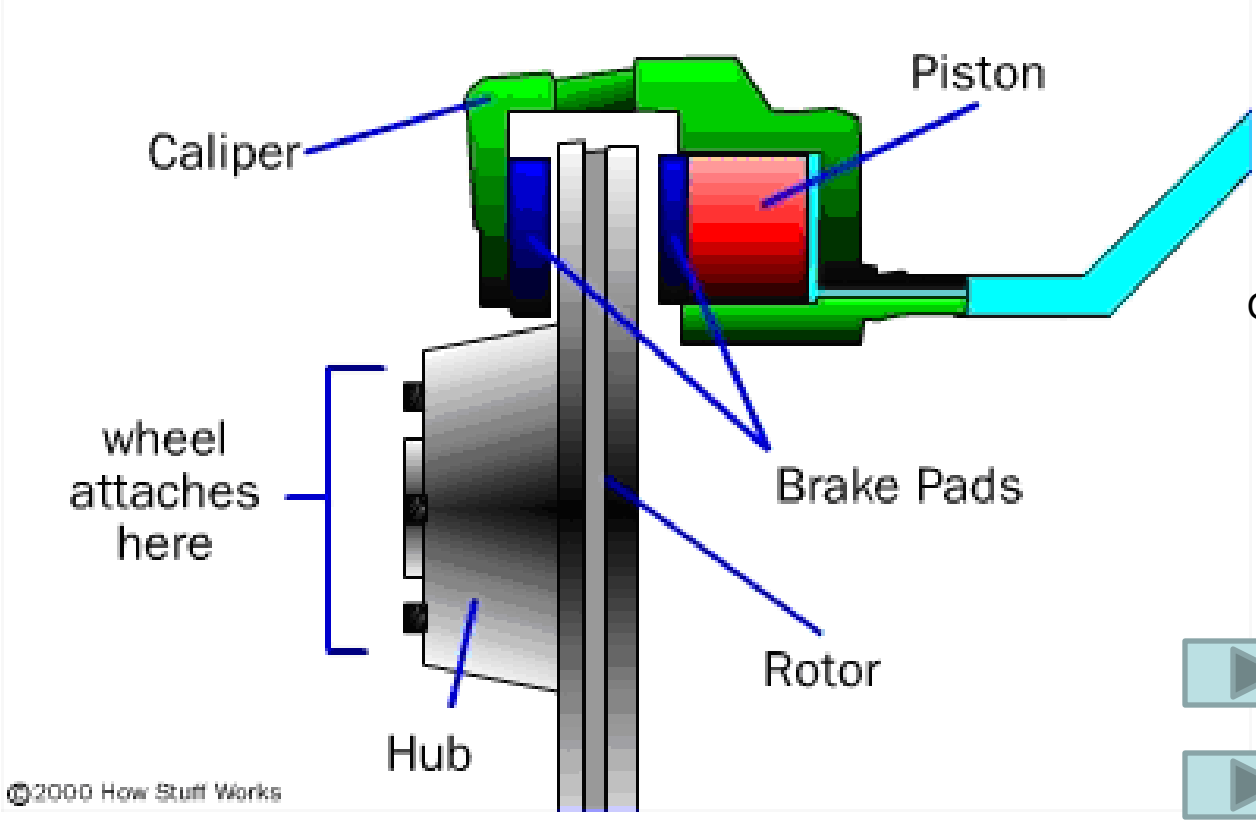


Caliper fixo



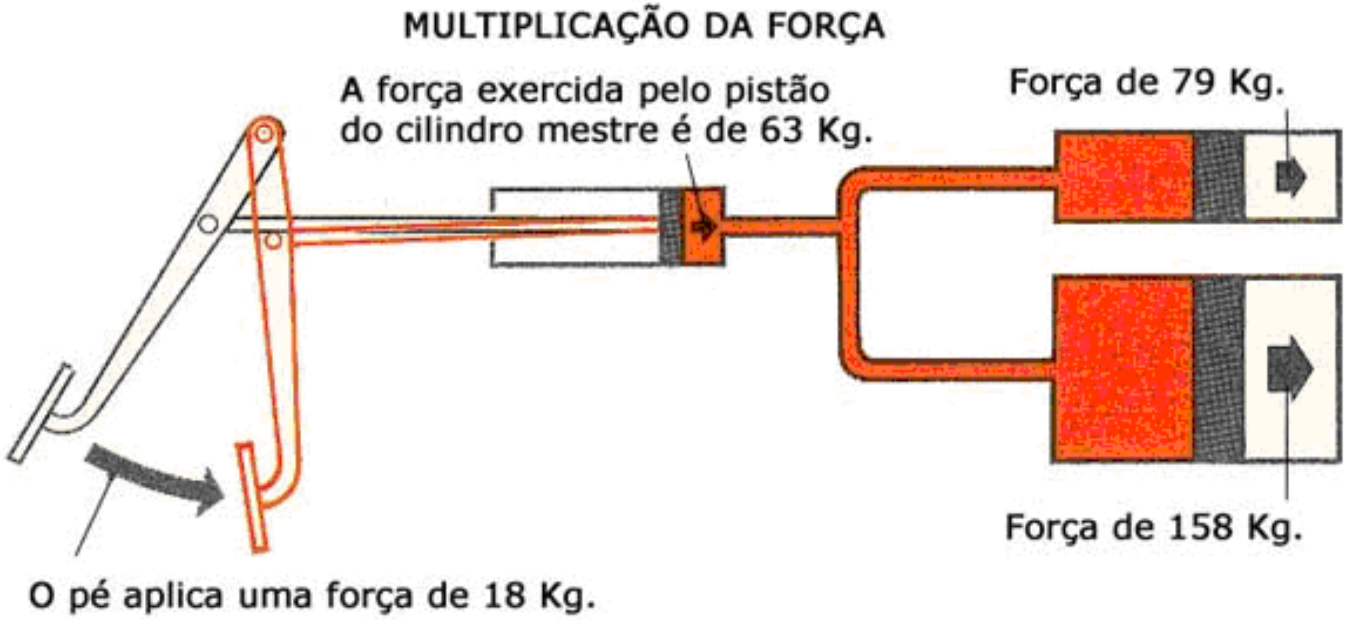
(1) Carcaça externa; (2) parafuso de junção; (3) anel de vedação; (4) canal de fluido; (5) pastilha de freio; (6) disco de freio; (7) guarda pó de borracha; (8) êmbolo; (9) carcaça interna flangelada; (10) furo de alimentação de fluido; (11) flange de montagem.

Caliper móvel



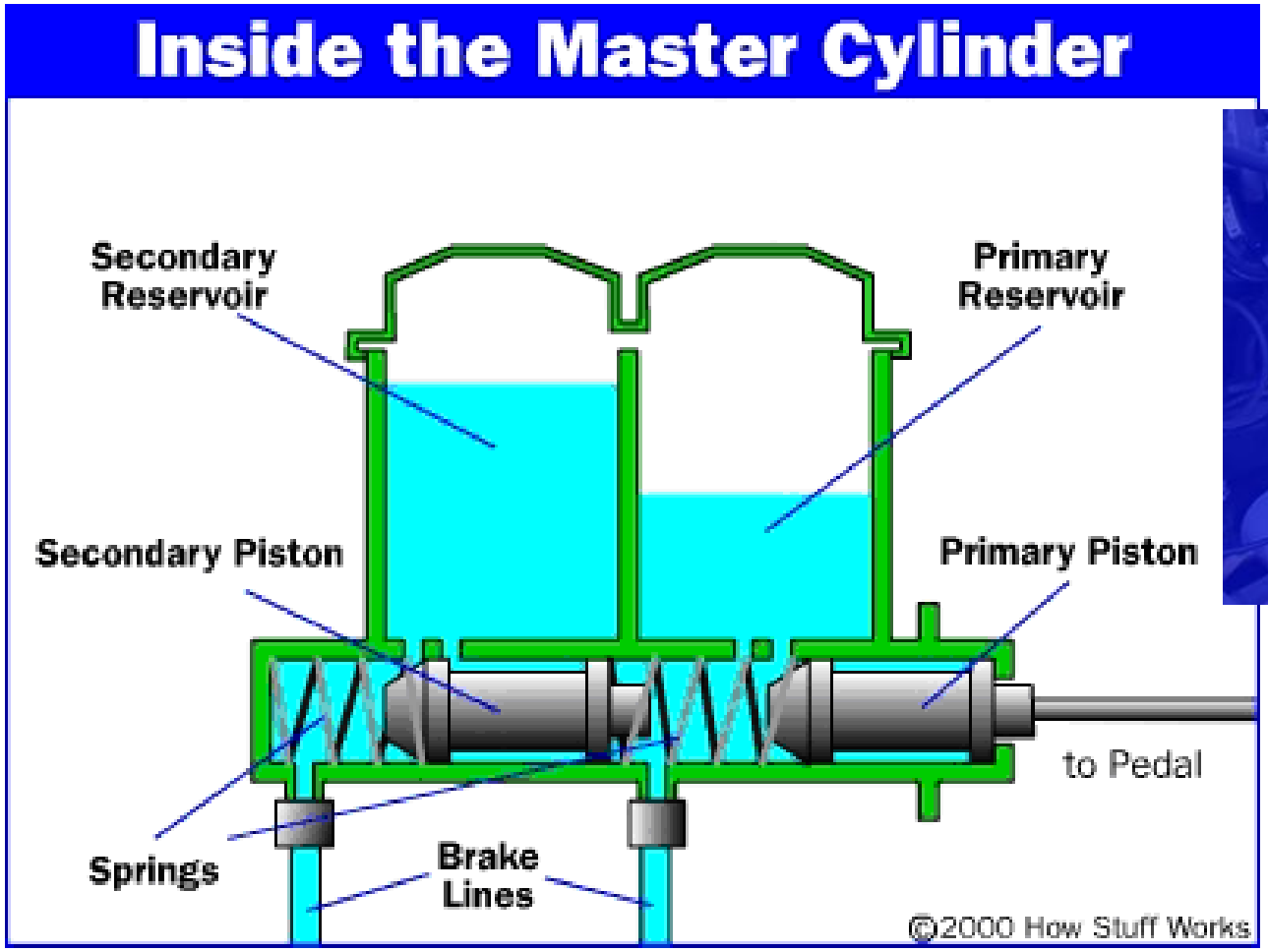
Caliper móvel

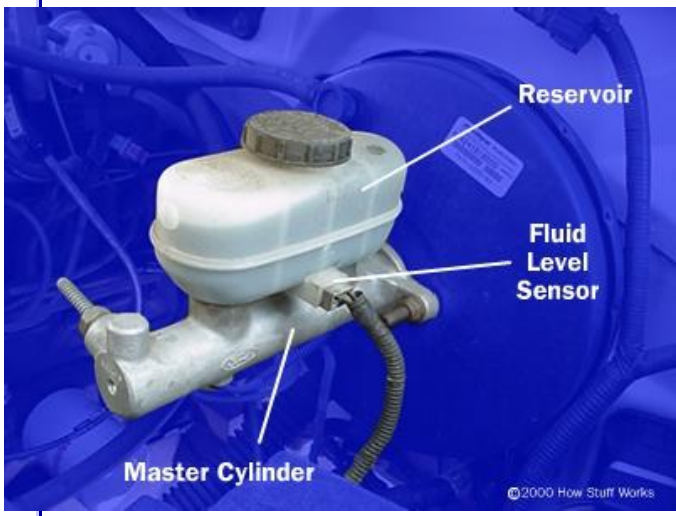
Ganho de força




Blaise Pascal
1623 - 1662

Cilindro mestre – duplo circuito

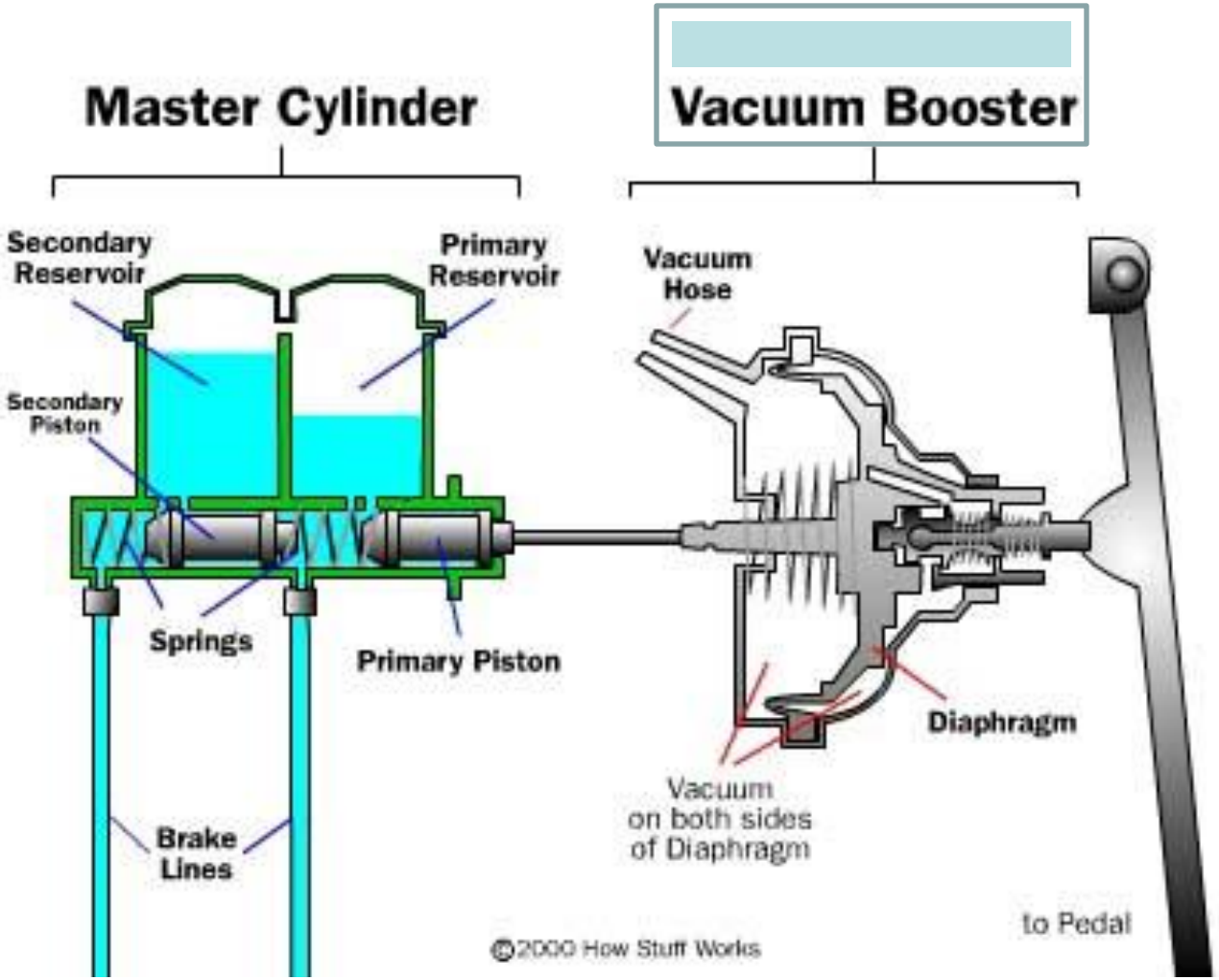




Funcionamento normal

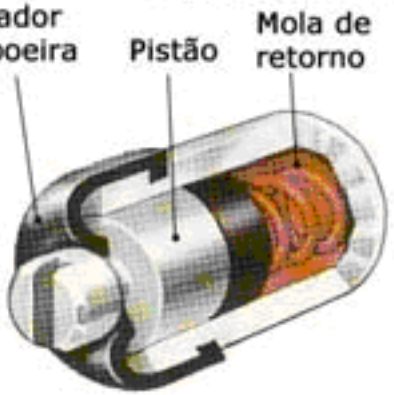
Falha no funcionamento

TANDEM MASTER CYLINDER


Master Cylinder
Vacuum Booster
Secondary Reservoir
Primary Reservoir
Secondary Piston
Springs
Primary Piston
Brake Lines
Vacuum Hose
Diaphragm
Vacuum on both sides of Diaphragm
to Pedal
©2000 How Stuff Works

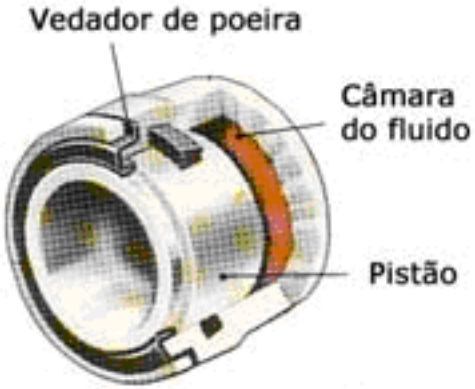
Modelos de cilindros de freio

OUTROS MODELOS DE CILINDROS DE FREIO



CILINDRO DE EFEITO SIMPLES

Este modelo possui apenas um pistão, pelo que o cilindro também se move em substituição do segundo pistão.



CILINDRO DO FREIO À DISCO

Dois pistões como na figura, acionam pressão as pastilhas de fricção às duas faces do disco.

Freio a tambor - hidráulico

Legenda:

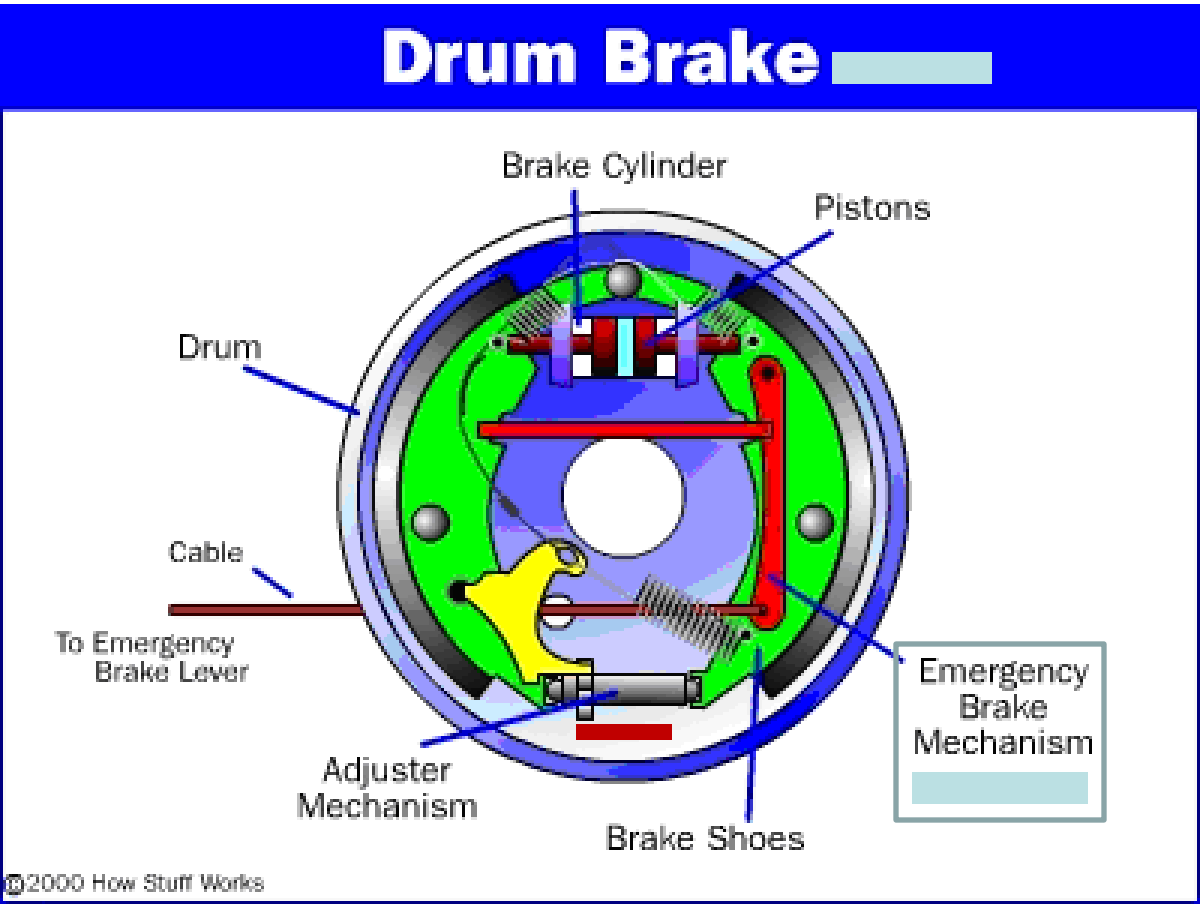
1-) Tambor Está preso ao cubo da roda

2-) Cilindro É ele quem recebe a pressão exercida pelo motorista sobre o pedal do freio, e se expande, forçando as sapatas contra o tambor.

3-) Sapata Peça resistente que é forçada contra o tambor, gerando atrito e ocasionando a frenagem.

4-) Lona Reveste externamente a sapata, pois tem maior capacidade de provocar atrito.

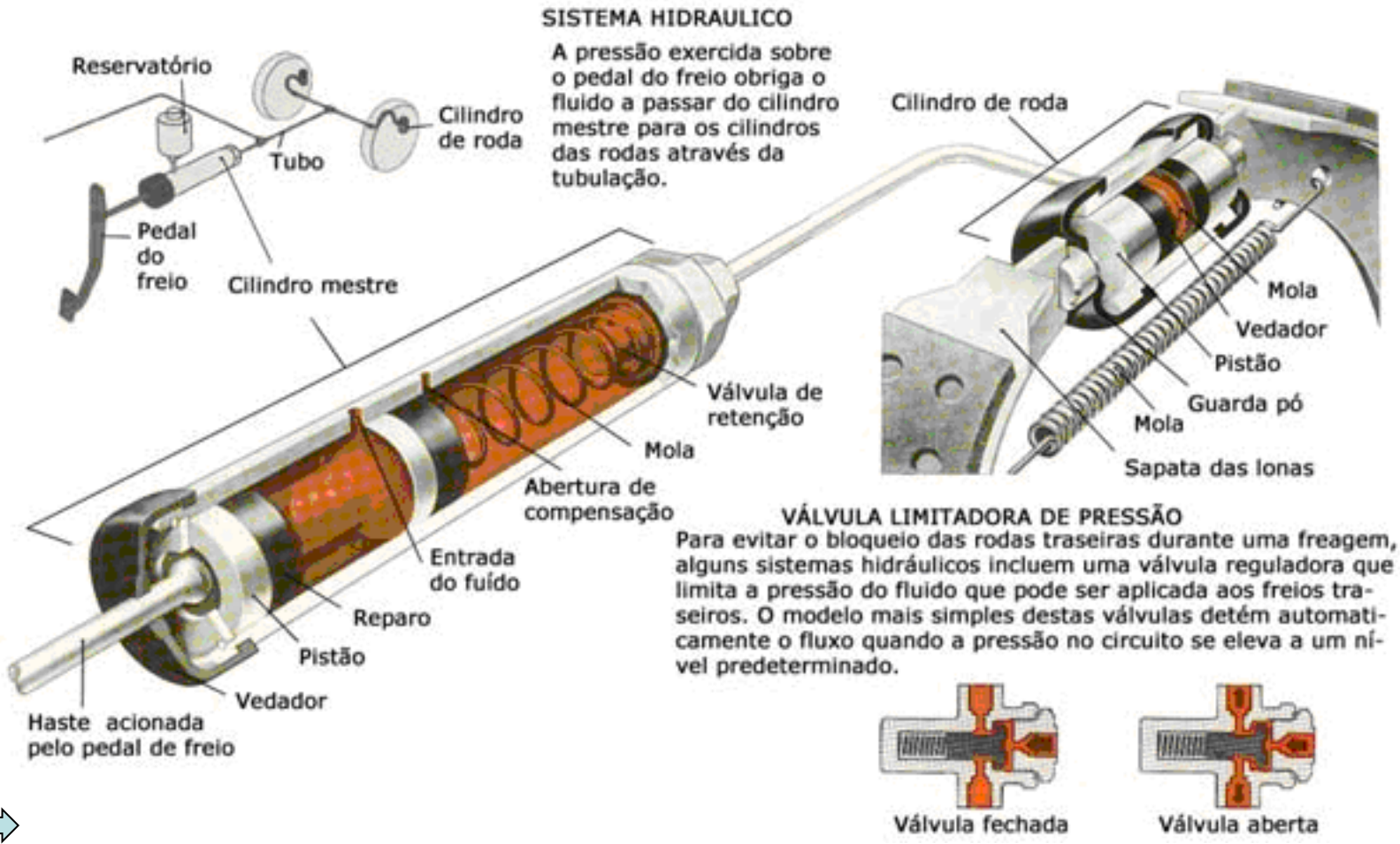
Freio a tambor - hidráulico

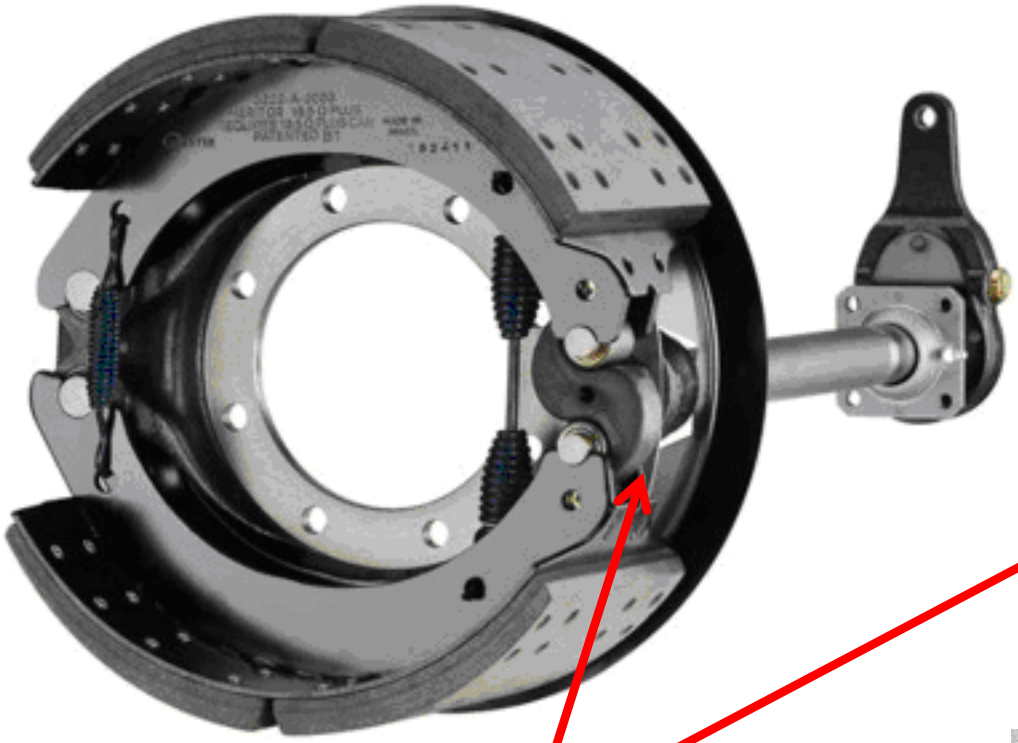


tambor

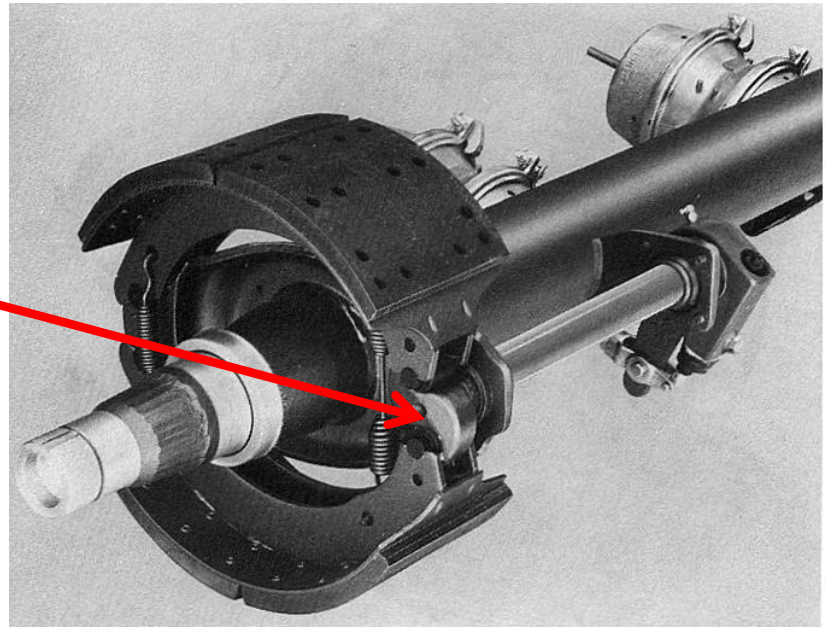
patim

Cilindro mestre e cilindro de roda freio a tambor

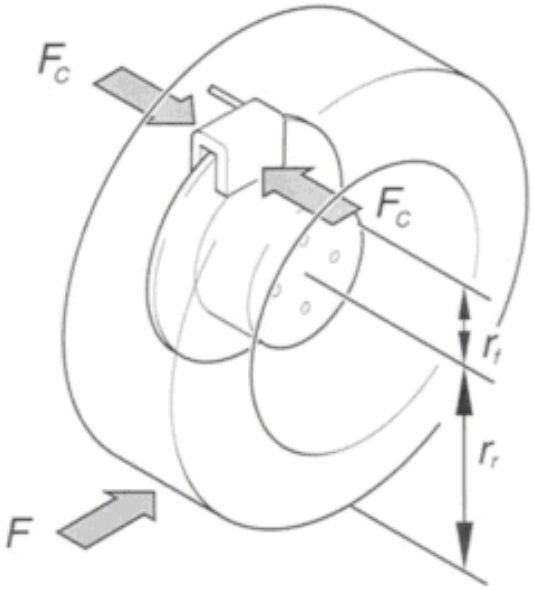


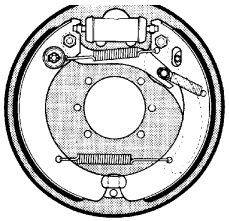


Freio S came

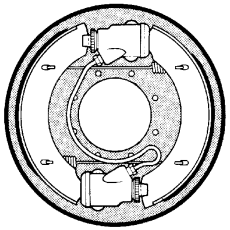


Raio efetivo S came

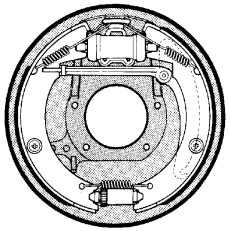




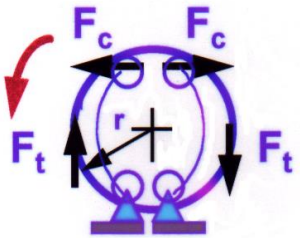
Leading-Trailing Shoe Brake

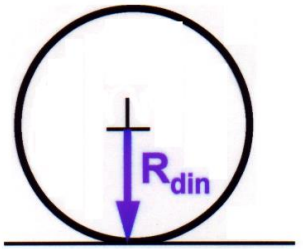


Two-Leading Shoe Brake



Duo-Servo Brake





Forças reais:

ex: freio a tambor com acionamento hidráulico

$F_c = p.\ A_c$

fator de freio: $C^* = F_t / F_c$

$F_t = F_c\ .\ C^* = p.\ A_c.C^*$

torque real: $T_r = 2.\ F_t\ .r\ = F_r\ .\ R_{din}$

portanto: $F_{ED/\ ET} = 2.\ p.\ A_c.\ C^*.\ r.\ \eta\ /\ R_{din}$ **reta**

considerando: $\mu_f = \mu_r = \mu_O$

as forças de freagem serão máximas se:

$B_f = \mu_f .Wb_f = \mu\ .Wb_f = \mu\ .(W/g).(\ (1-\alpha\ ) + b.\phi\ )$ (3)

$B_r = \mu_r .Wb_r = \mu\ .Wb_r = \mu\ .(W/g).(\ \alpha - b.\phi\ )$ (4)

onde: $\phi = H / L$ e $\alpha = L_f / L$

realizando: $\Sigma F_x : R_i = B_f + B_r$ (5)

$W.b/g = \mu\ .(Wb_f + Wb_r) = \mu\ .W$

tem-se que: $\mu = b/g$

partindo de: $(B_r / W) = (b / g\ ) - (B_f / W)$ (5):

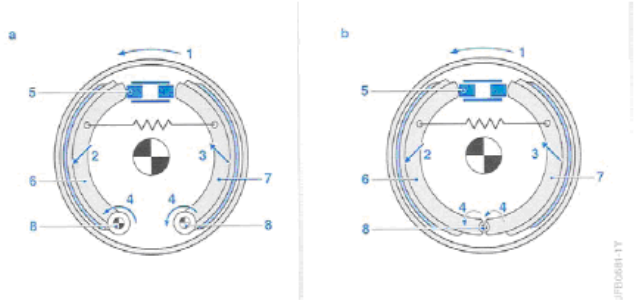
tem-se:

$B_r / W = (\ ((1-\alpha\ ) / 2.\phi\ )^2 + (B_f/\phi\ .W)\ )^{1/2}$ **parábola**

$- (B_f / W) - ((1-\alpha\ )/ 2.\phi\ )$

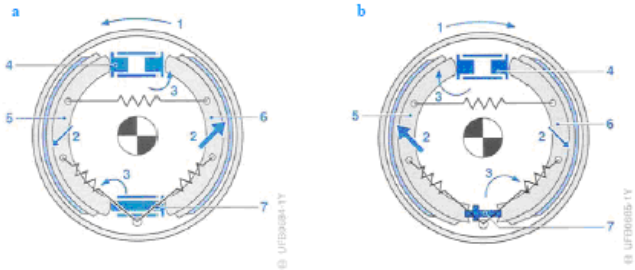
Fator de freio

Simulador geral



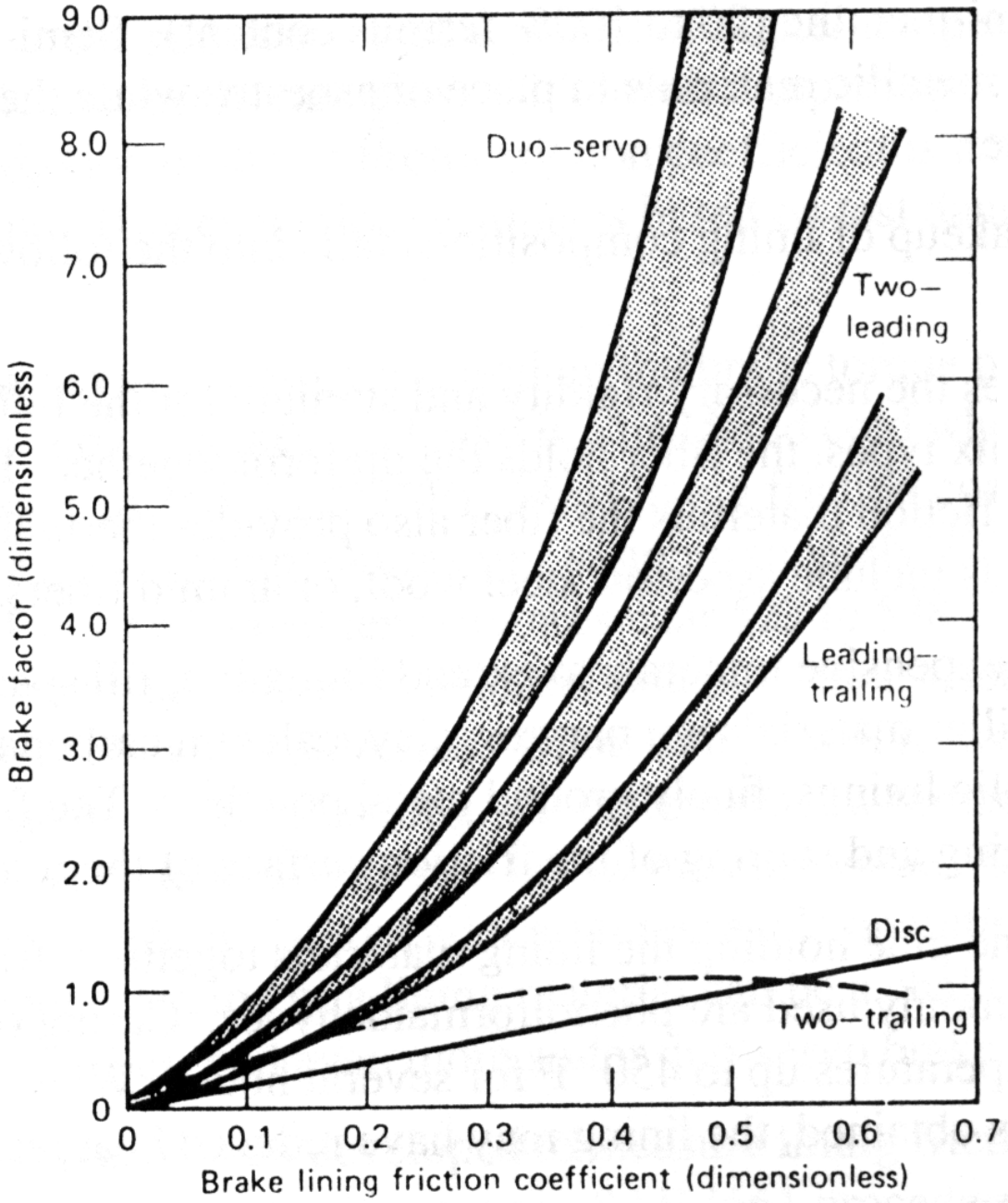
(1) direção de rotação; (2) efeito auto-energizamento; efeito auto-inibimento; (4) torque; (5) cilindro de roda de dupla ação; (6) e (7) sapatas; (8) ponto de ancoragem.

Leadin trailing



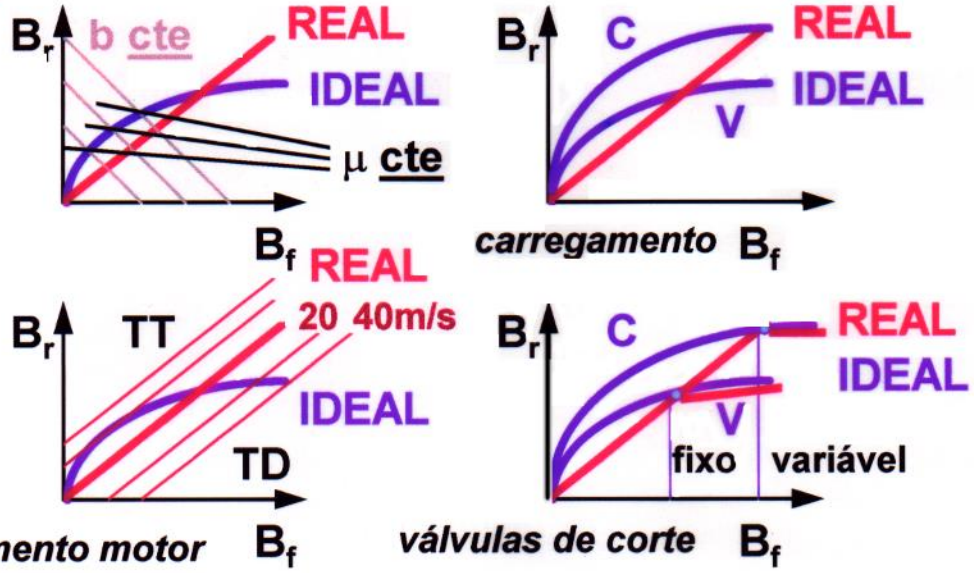
(1) direção de rotação; (2) efeito auto-energizamento; (3) torque; (4) cilindro de roda; (5) ponto de apoio; (6) sapatas de freio; (7) pino de pressão.

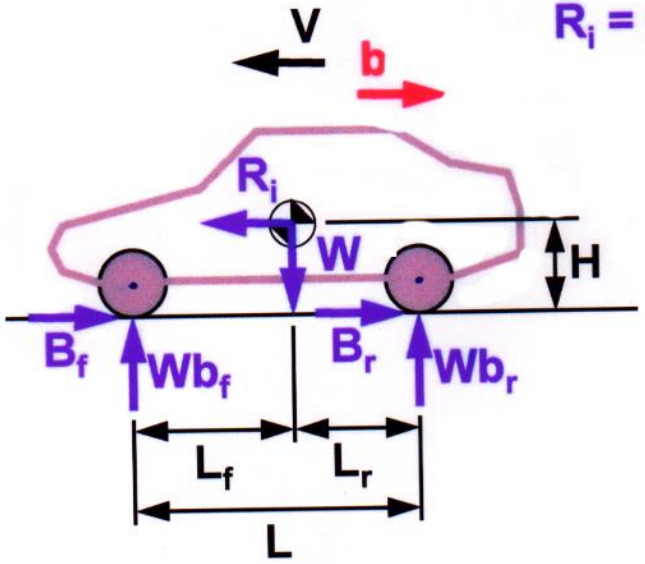
Duo servo



Frenagem 30

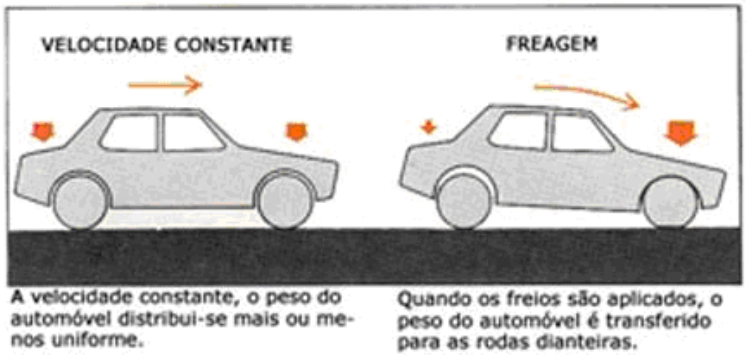
Distribuição das forças de frenagem





$R_i = m.b = W.b / g$

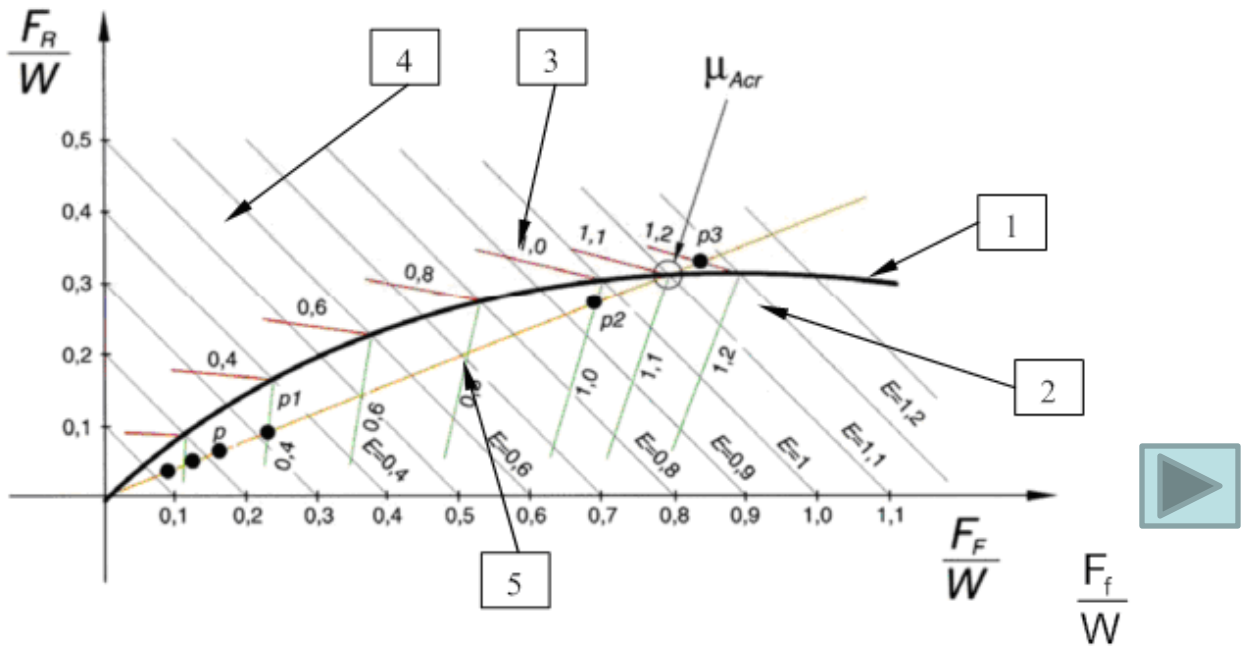
balanceamento ideal x balanceamento real

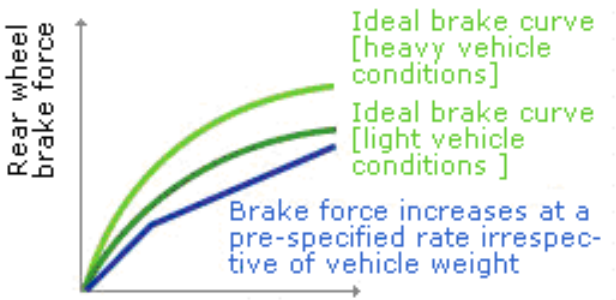


condição dinâmica: $Wb_f = (W/g).((L- L_f) + b.H) / L$

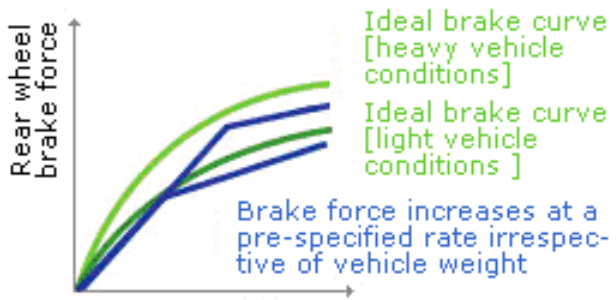
$Wb_r = (W/g).(L_f - b.H) / L$

Distribuição das forças de frenagem





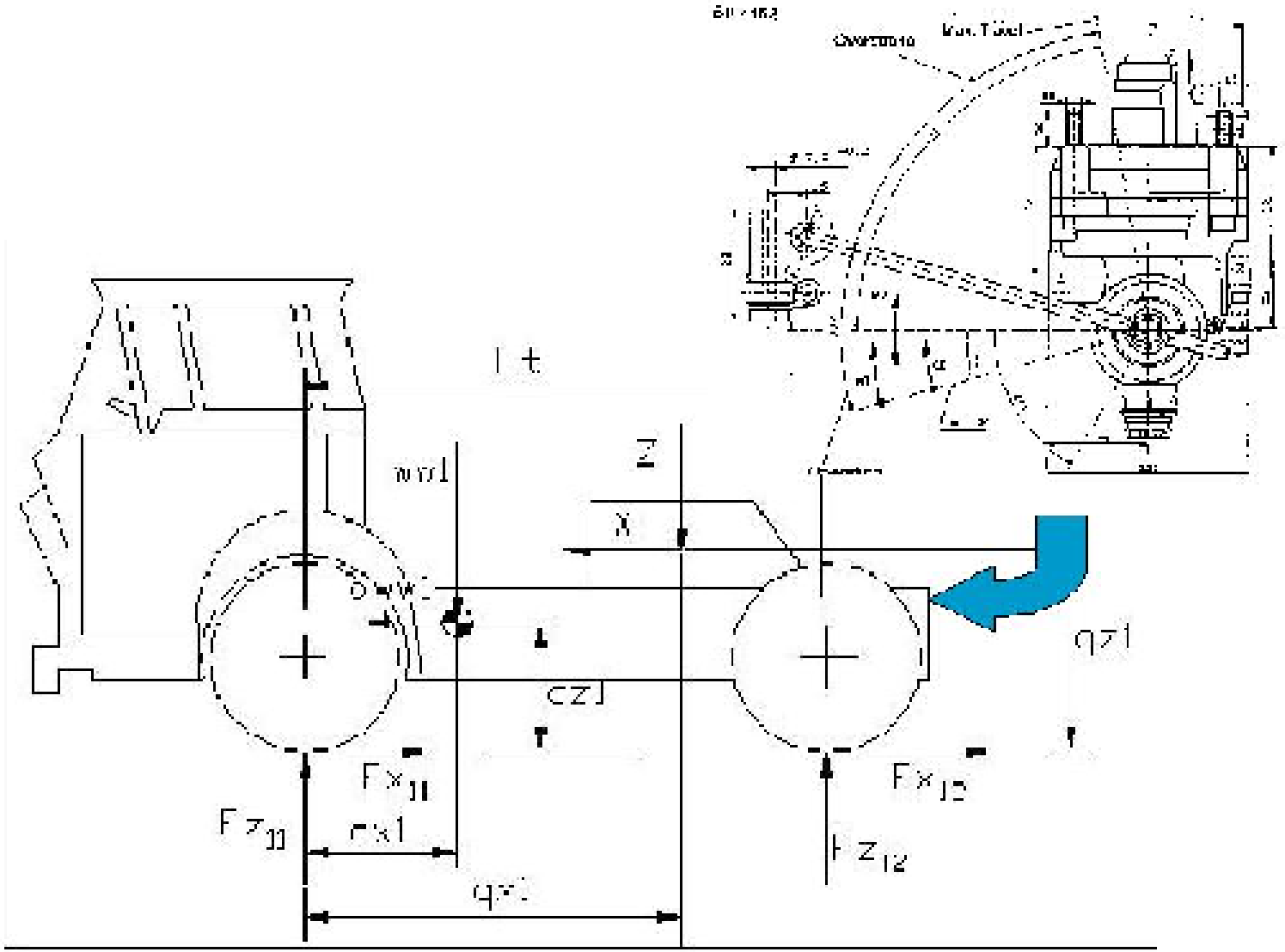
Existing propositioning value applied



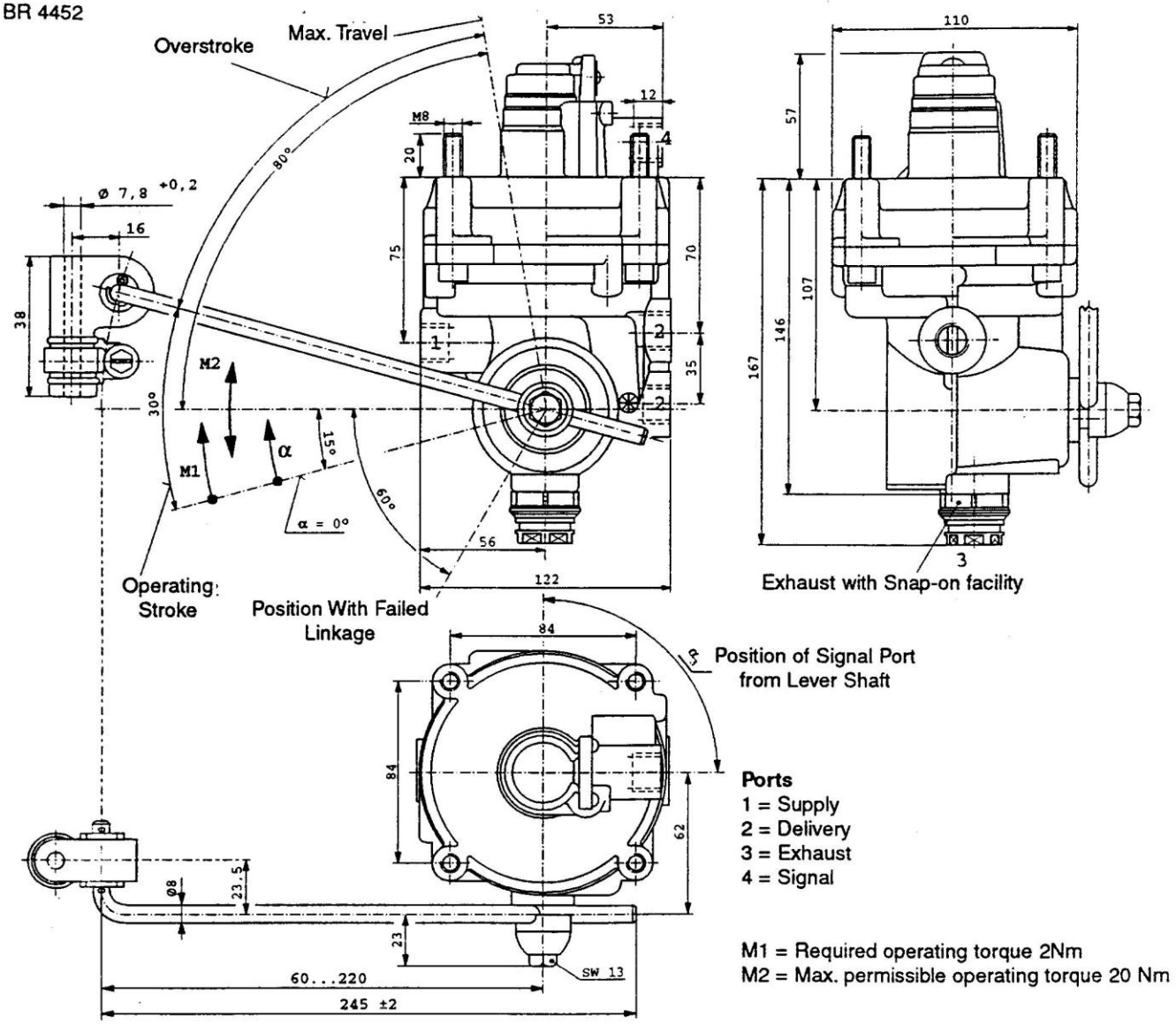
EBD applied

- The closer to the ideal brake curve for a particular vehicle weight, the bigger larger the brake force.

Cavalo mecânico



BR 4452



Ports
1 = Supply
2 = Delivery
3 = Exhaust
4 = Signal

M1 = Required operating torque 2Nm
M2 = Max. permissible operating torque 20 Nm

Curvas características da válvula ALB

<u>Diagrama A</u>: P_2/P_4 (alfa = 0 e alfa = 30)

<u>Diagrama B</u>: P_2 com alfa (P_4 = 7,5 bar)

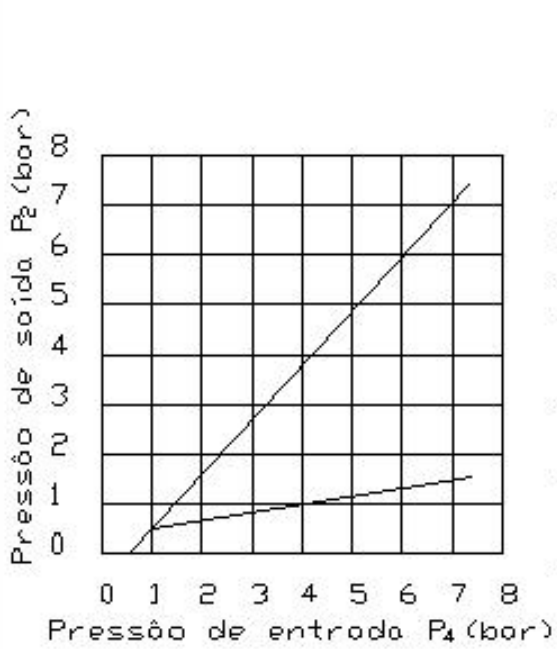


Diagrama A

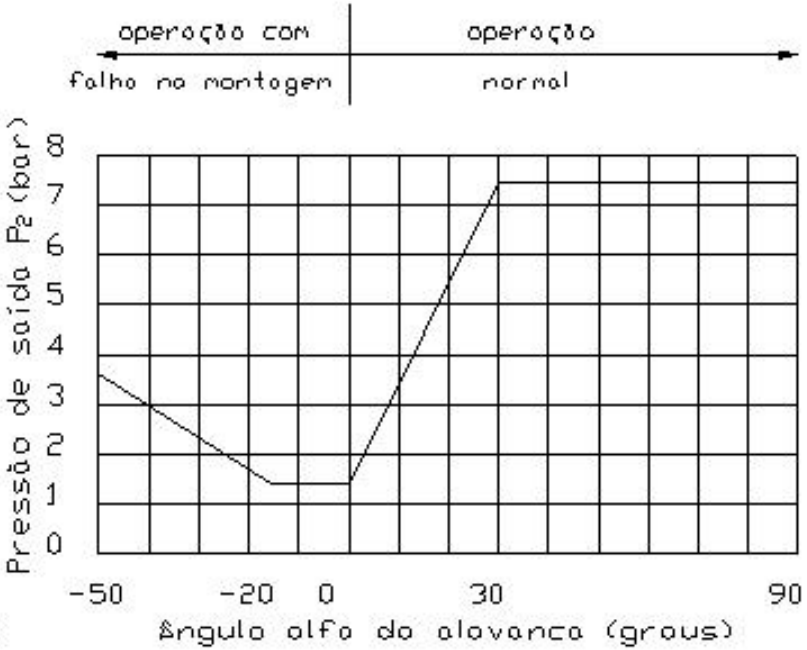
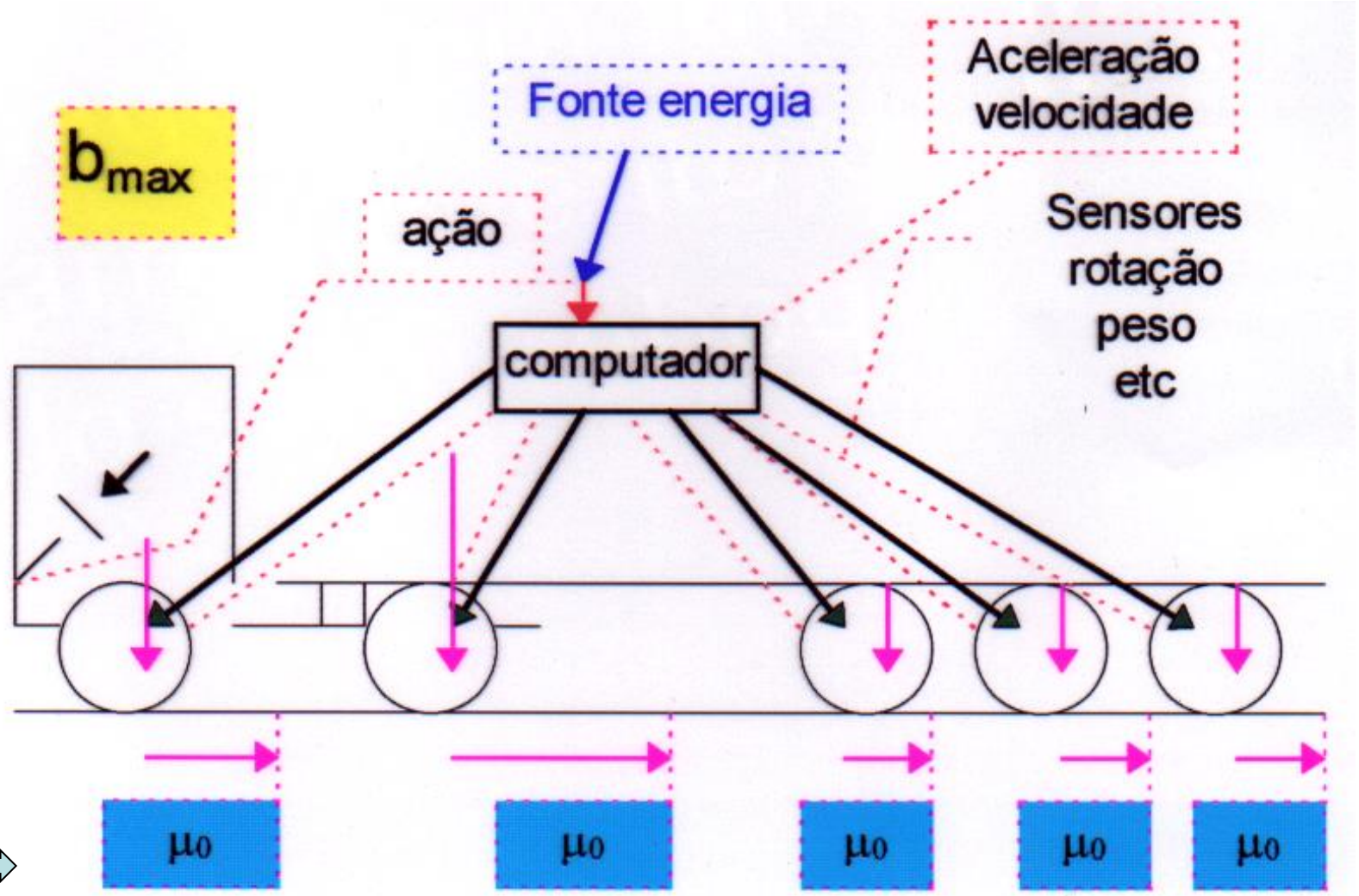
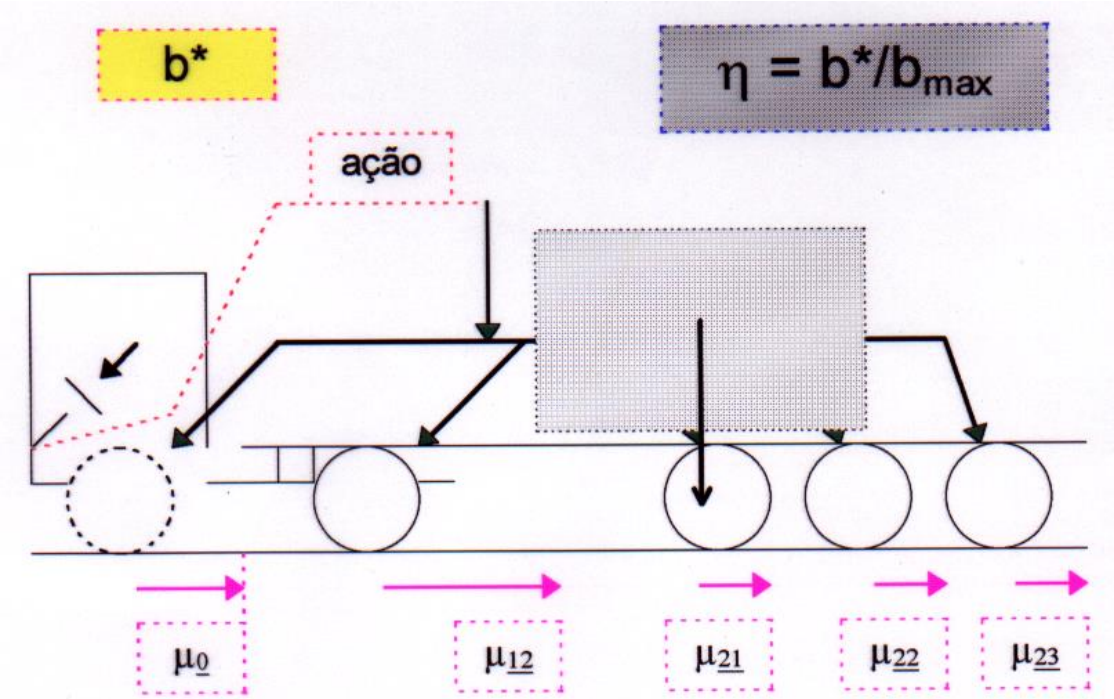


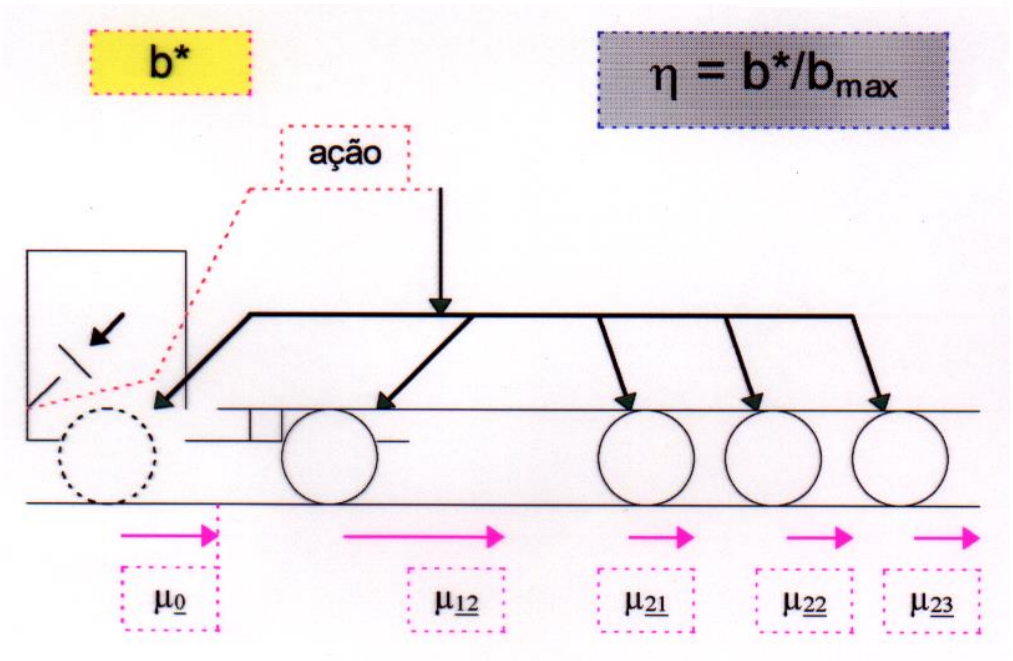
Diagrama B

Veiculo com freio de alto desempenho

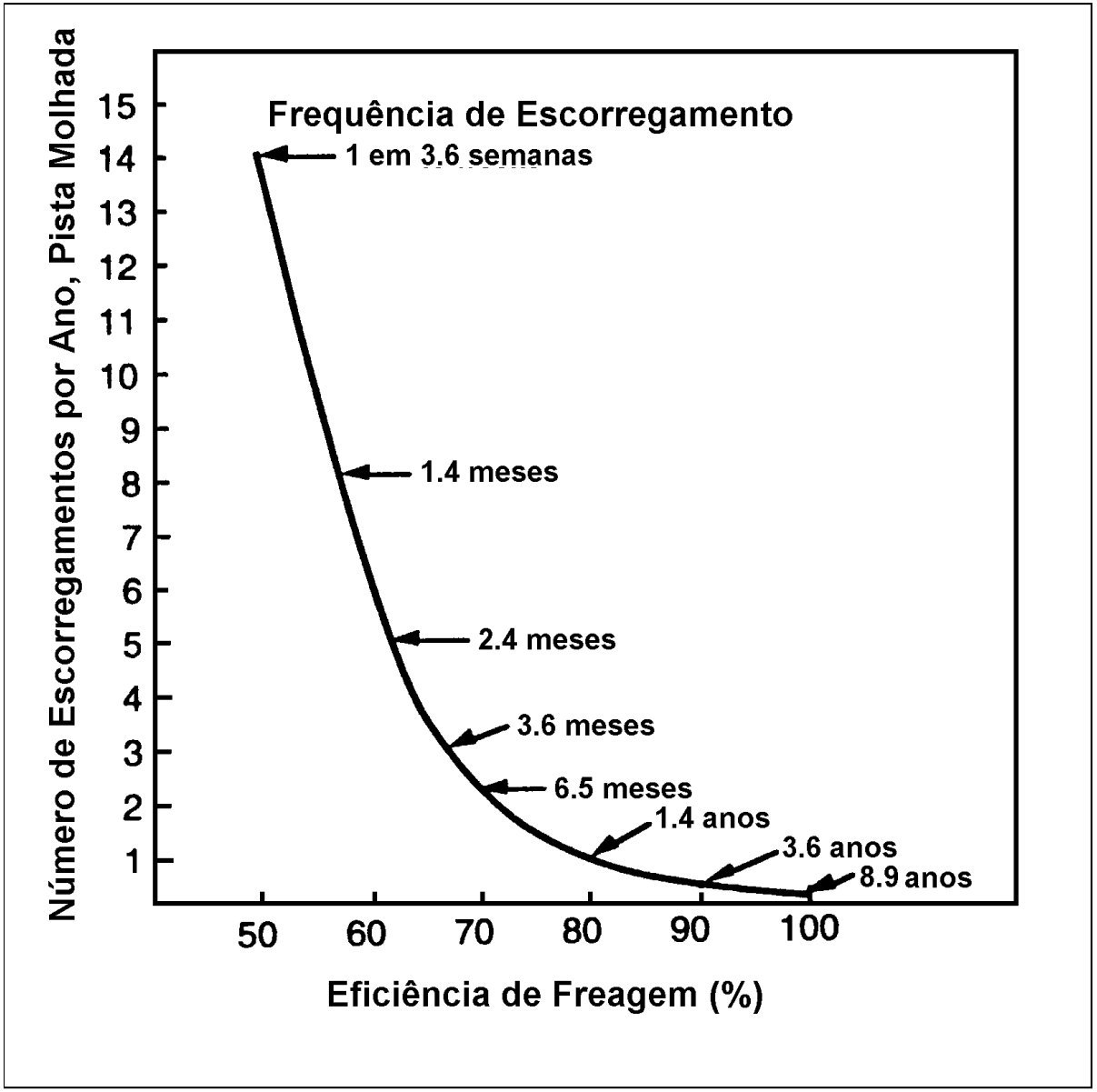


eficiência


b*
η = b*/bmax
ação
μ0
μ12
μ21
μ22
μ23

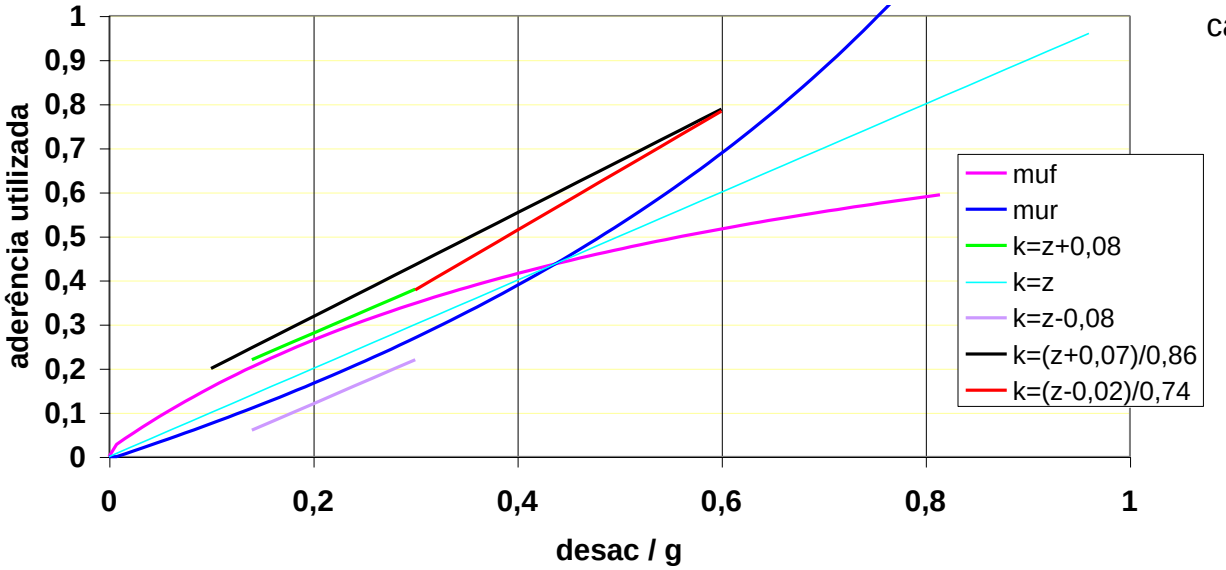

b*
η = b*/bmax
ação
μ0
μ12
μ21
μ22
μ23

Eficiencia x segurança



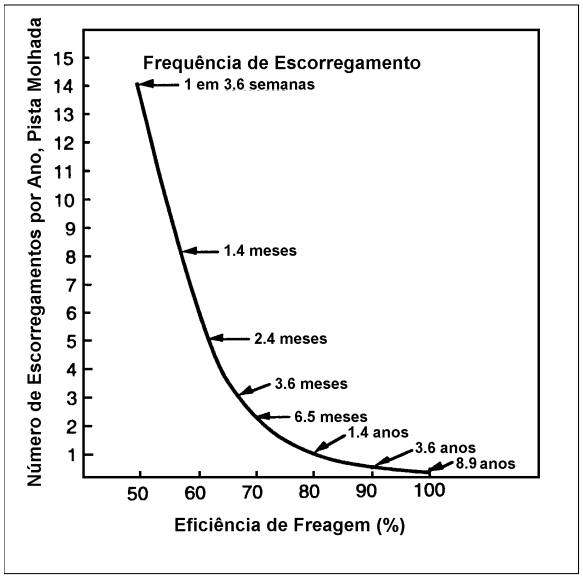
Veículo exemplo carregado - com válvula sensível à carga - Anexo 10 ECE-R13

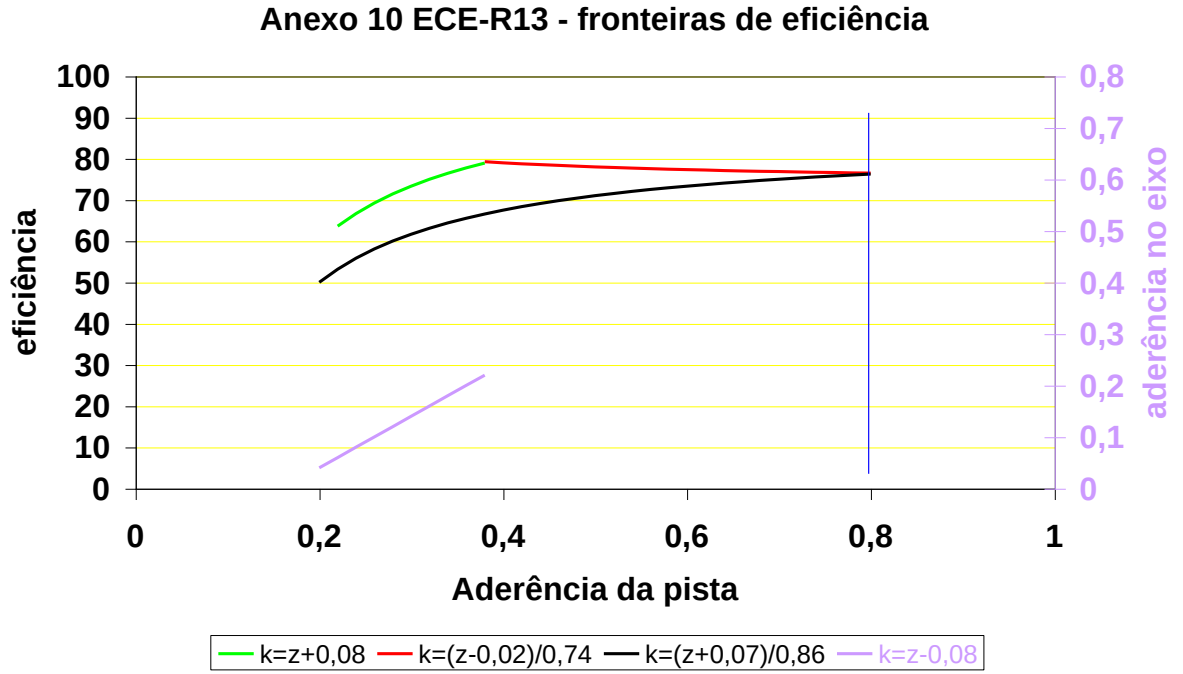
carregado Vazio c/ Vazio s/



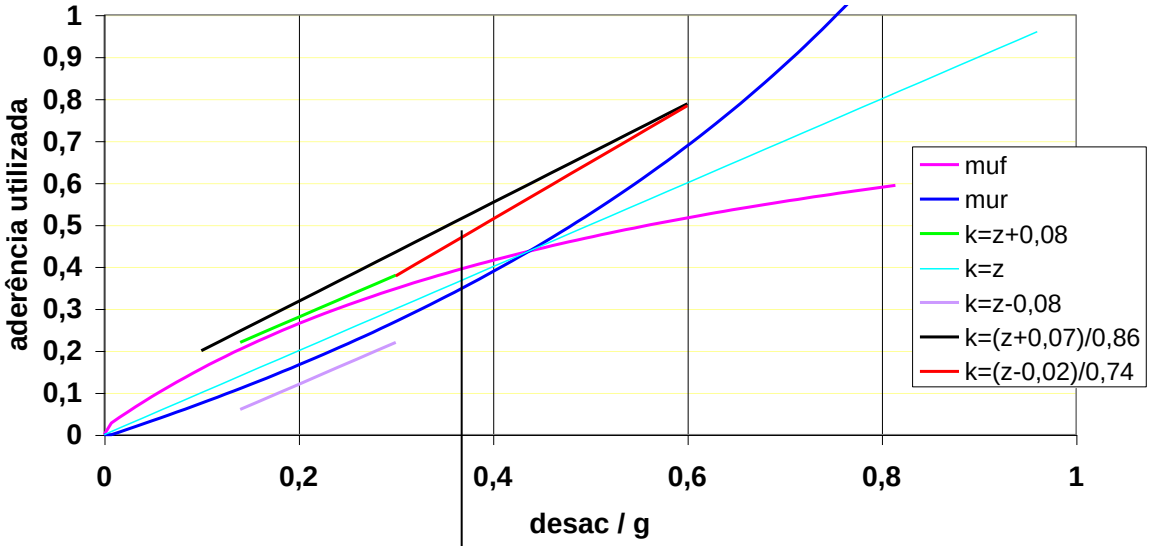
NBR 14354

AGO 1999





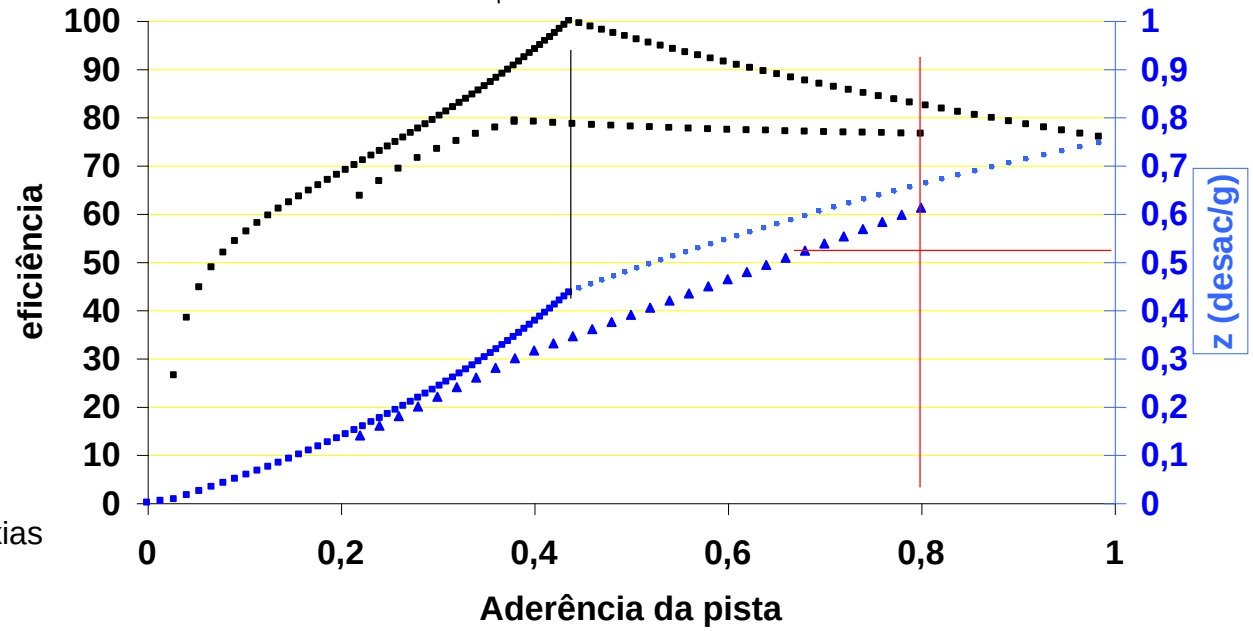
Veículo exemplo carregado - com válvula sensível à carga - Anexo 10 ECE-R13



NBR 14354

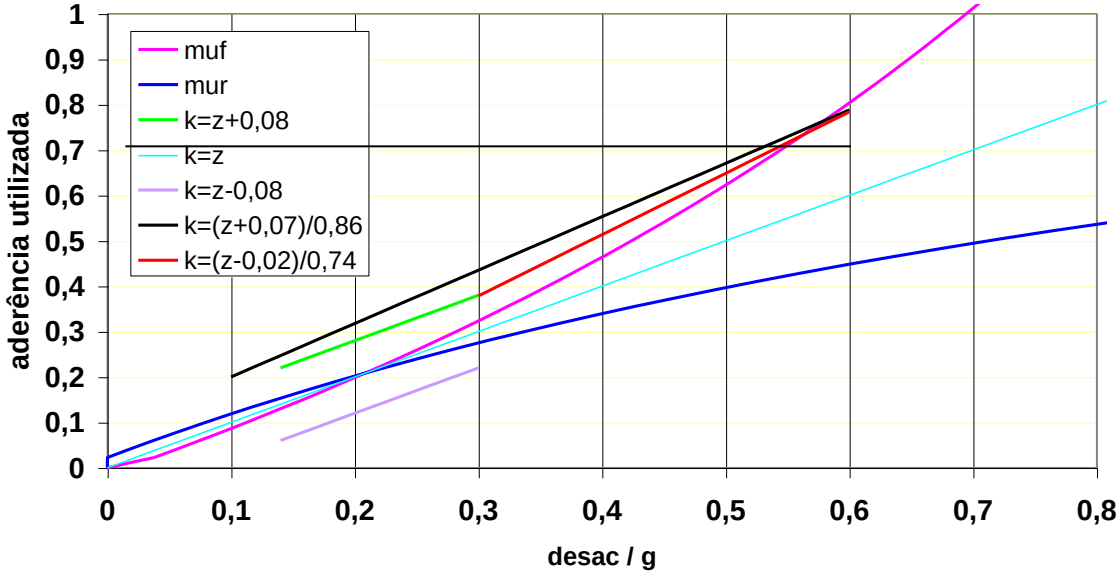
AGO 1999

Veículo exemplo carregado - c/ válvula LSV - Anexo 10 ECE-R130



Veículo exemplo vazio - com válvula sensível à carga - Anexo 10 ECE-R13

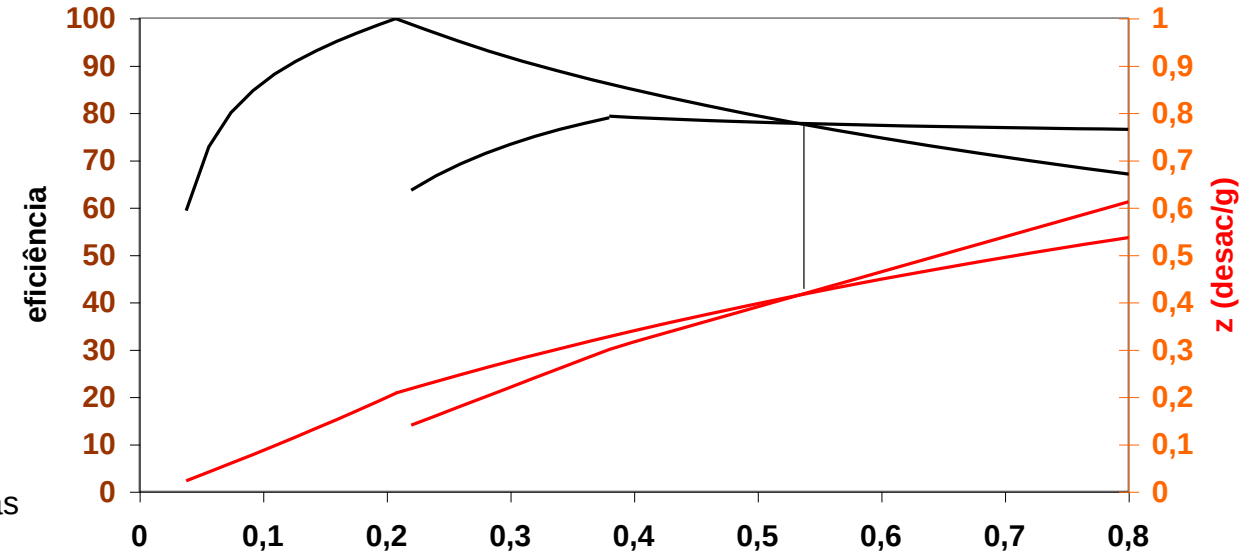
Valvula



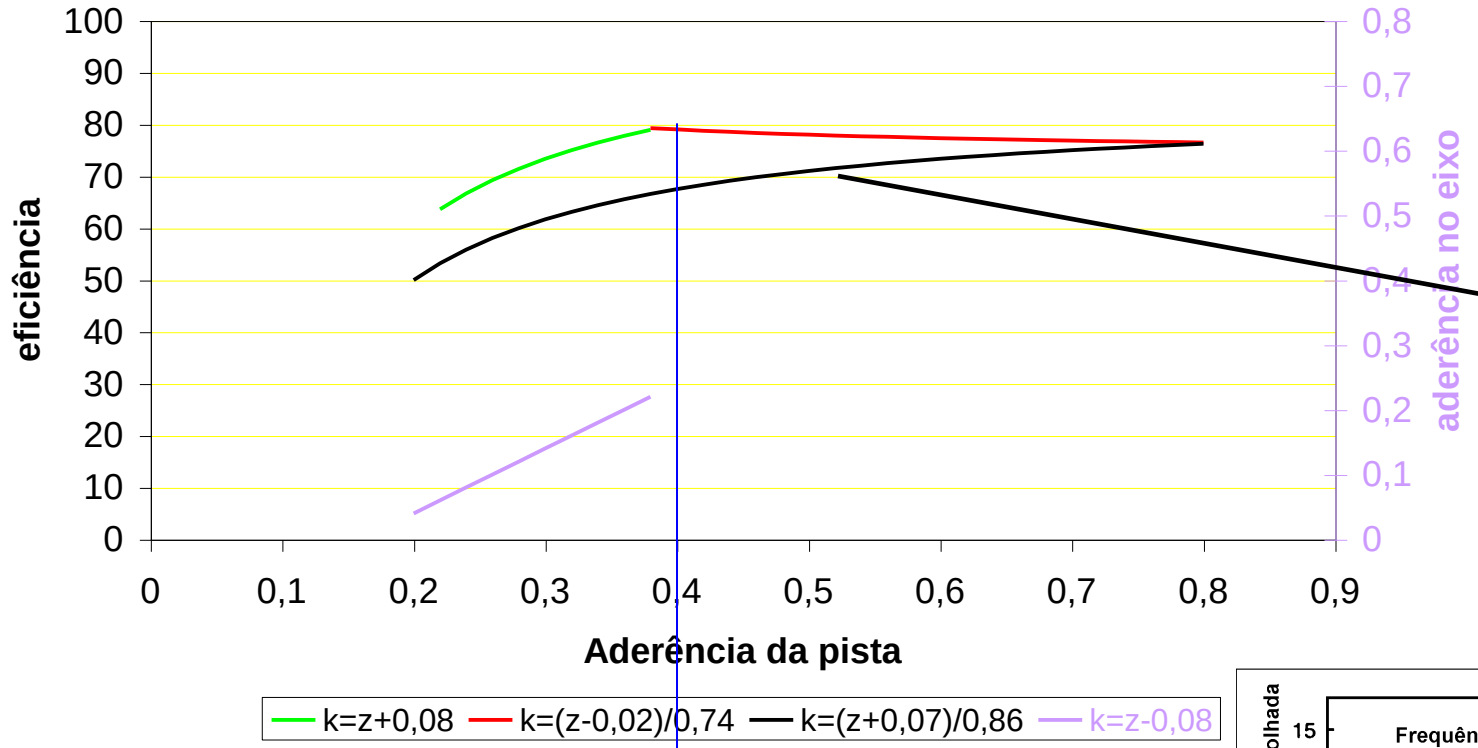
Sem a valvula

Simuador geral

ECE R13 anexo 10 - veículo vazio - sem válvula sensível à carga



Anexo 10 ECE-R13 - fronteiras de eficiência

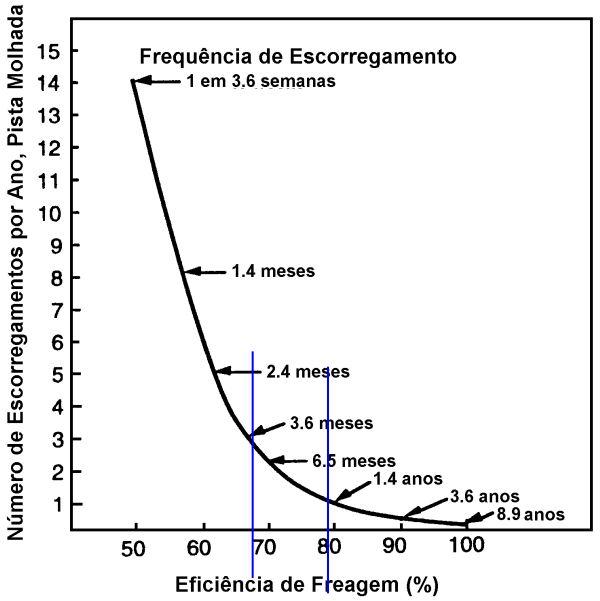


PROBABILIDADE
ESCORREGAMENTO

Uso do ABS

NBR 14353

AGO 1999



COMPATIBILIDADE CAVALO - SEMIREBOQUE

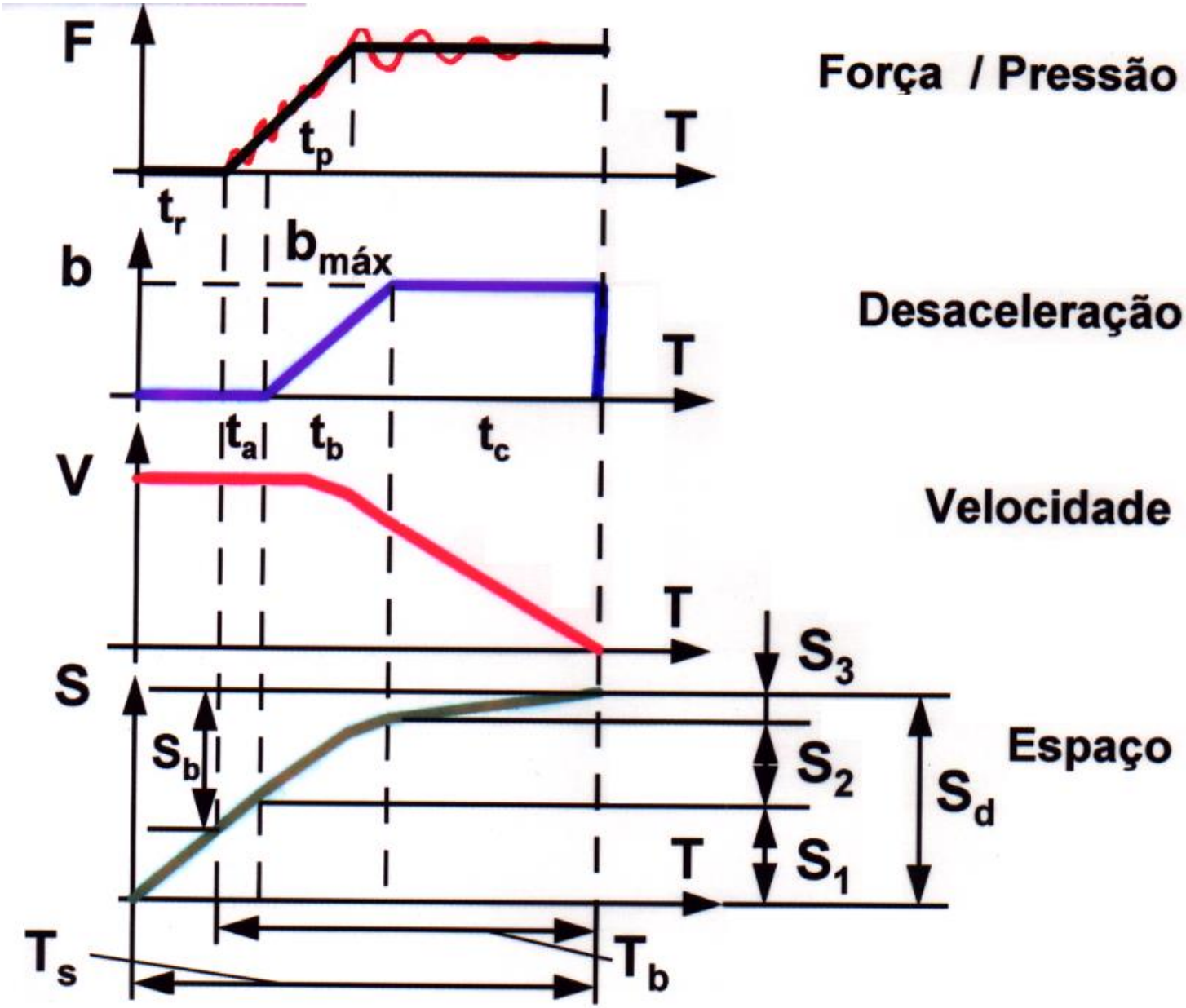
- Em veículos combinados, deve haver compatibilidade de potência de frenagem entre o cavalo e o semi-reboque, caso contrário, haverá deslizamento das rodas de um deles prematuramente gerando movimentos instáveis com o jackknife e o swing trailer.

ABNT 14354

Compatibilidade semi-reboque

Compatibilidade cavalo

Compatibilidade semi-reboque


F
Força / Pressão
t_p
T
t_r
b
$b_{máx}$
Desaceleração
T
t_a
t_b
t_c
V
Velocidade
T
S_3
S
S_b
S_2
Espaço
S_d
T
S_1
T_s
T_b

Espaço e tempo de parada quando a desaceleração é constante – sem efeito da resistência do ar – tc = constante

EFICIÊNCIA DE 100%

$$S = \frac{\varphi_b}{g \times (\mu + f)} \times \left(\left(V_i^{\,2} - V_f^{\,2} \right) \div 2 \right)$$

$$t = \frac{\gamma_b}{g \times (\mu + f)} \times (V_i - V_f)$$

$$b = \frac{g}{\gamma_b} (\mu + f)$$

$\gamma_b = 1.05$

$\mu = 0.8$

$V_i = 60\,km / h$

$f = 0.01$

$S = 18.35$

$t = 2.20$

$b = 7.56$

Espaço e tempo de parada quando a desaceleração é constante – com efeito da resistência do ar – tc = constante

$$\rho = 1{,}22$$

$$A_f = 6$$

$$\gamma b = 1.05$$

$$\mu = 0.8$$

$$Vi = 60\,km/h$$

$$f = 0.01$$

$$S = 17{,}29$$

$$t = 2{,}12$$

$$b = 8{,}52$$

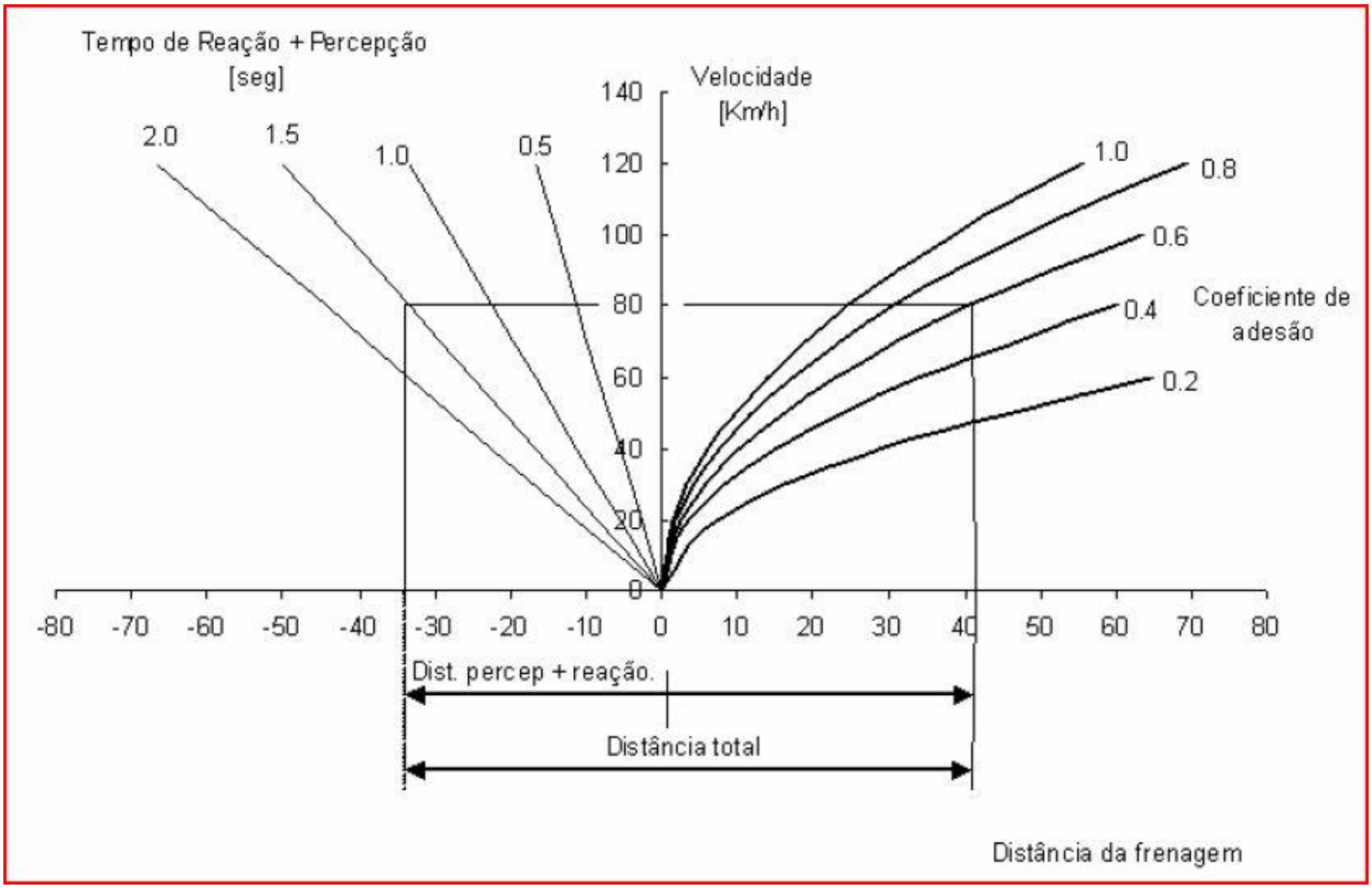
$$S = \frac{m \times \gamma_b}{2 \times C} \log_e\left(1 + \frac{C \times (V_i^2 - V_f^2)}{W \times (\mu + f)}\right)$$

$$C = 1/2 \times \rho \times Cd \times A_f \qquad Cd = 1$$

$$t = \frac{\gamma_b}{g} \times \sqrt{\frac{W}{C \times (\mu + f)}} \times tg^{-1}\left((V_i - V_f) \times \sqrt{\frac{C}{W \times (\mu + f)}}\right)$$

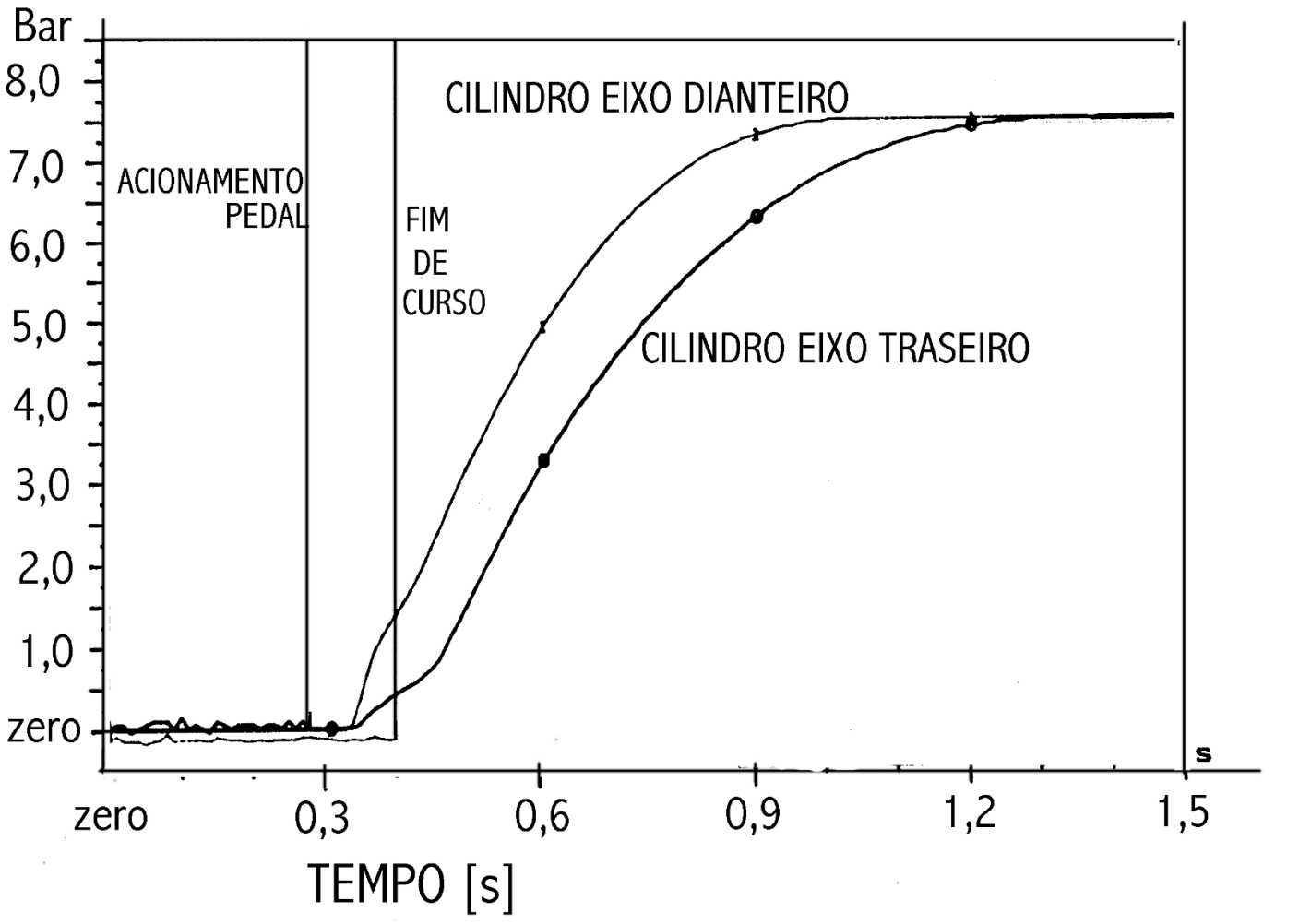
$$b = \frac{g}{\gamma_b} \times \left(\mu + f + \frac{R_a}{W}\right)$$

Espaço de parada com a reação do motorista

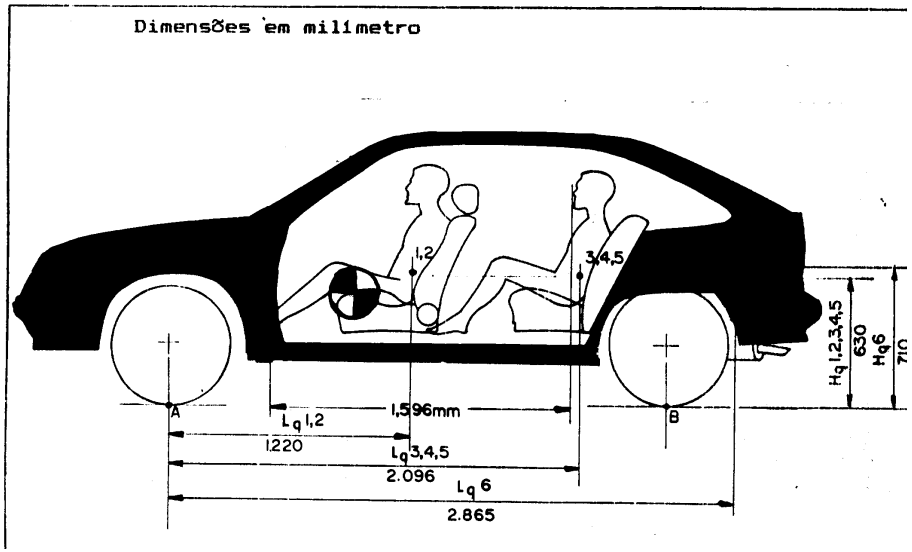


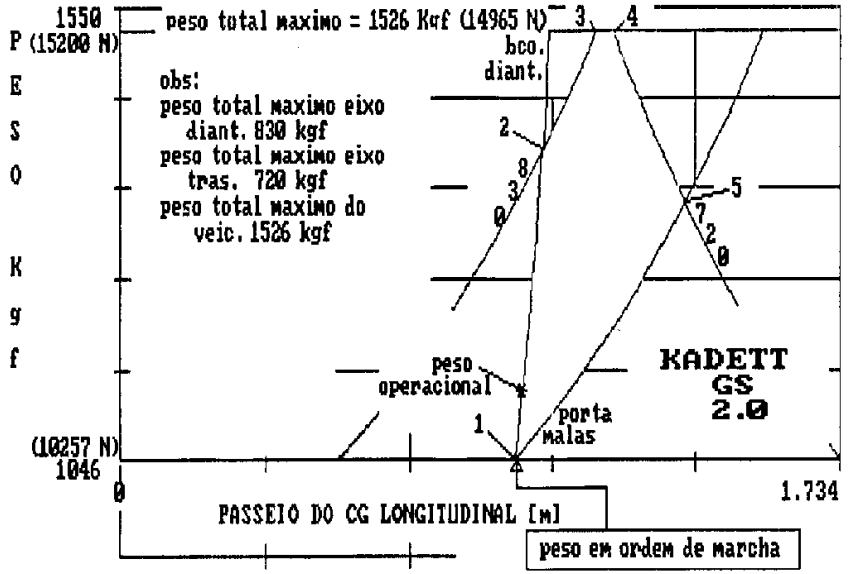
Tempo de resposta do freio

[ÔNIBUS]

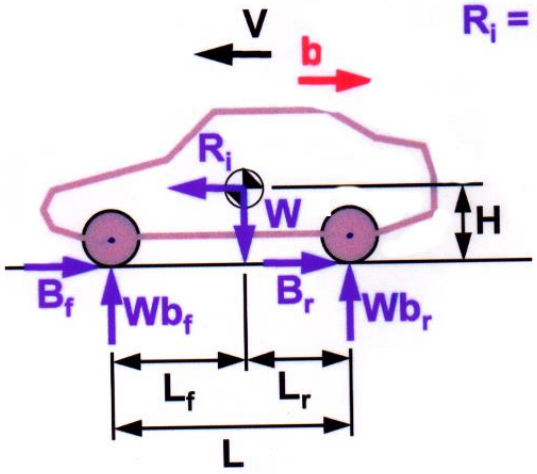


Simulação geral





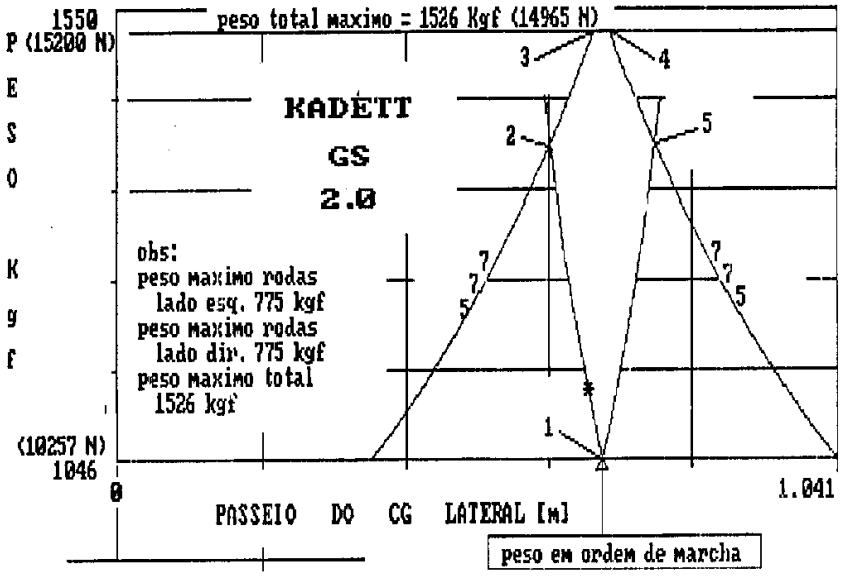
- Passeio do c.g. na longitudinal



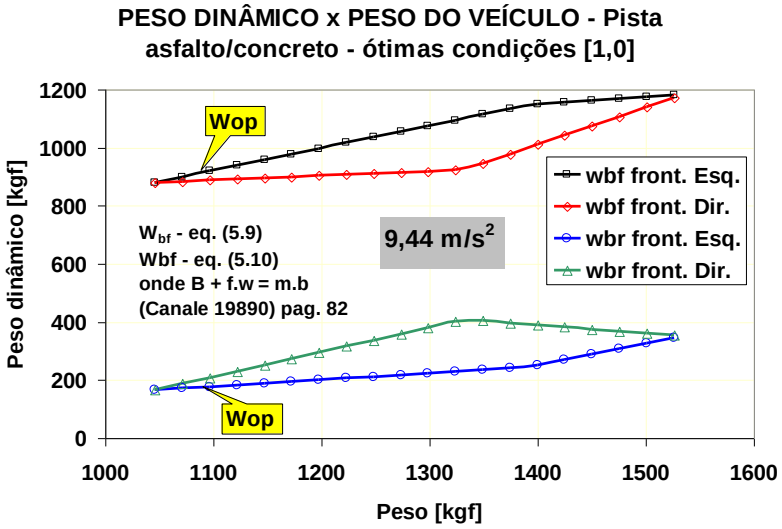
$R_i = m.b = W.b / g$

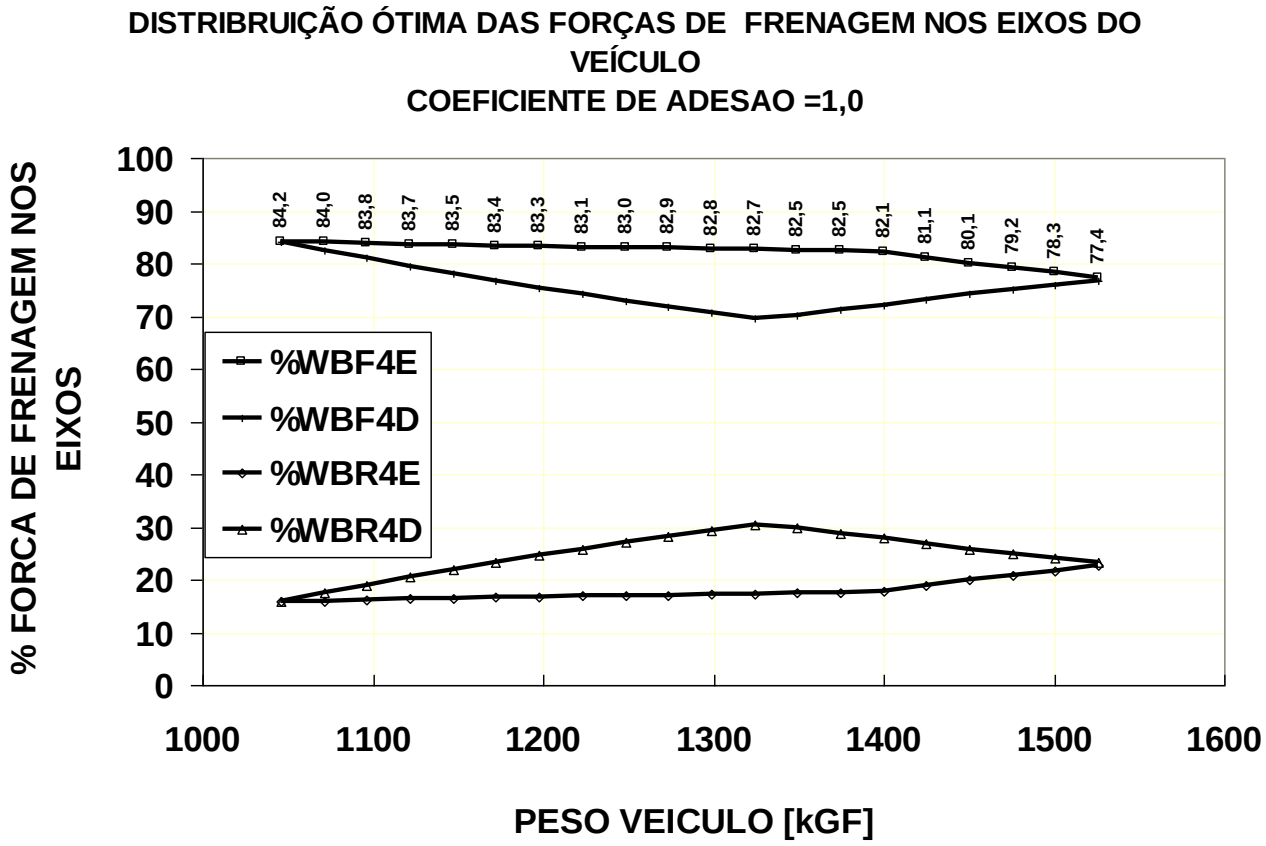
condição dinâmica: $Wb_f = (W/g).((L- L_f) + b.H) / L$

$Wb_r = (W/g).(L_f - b.H) / L$

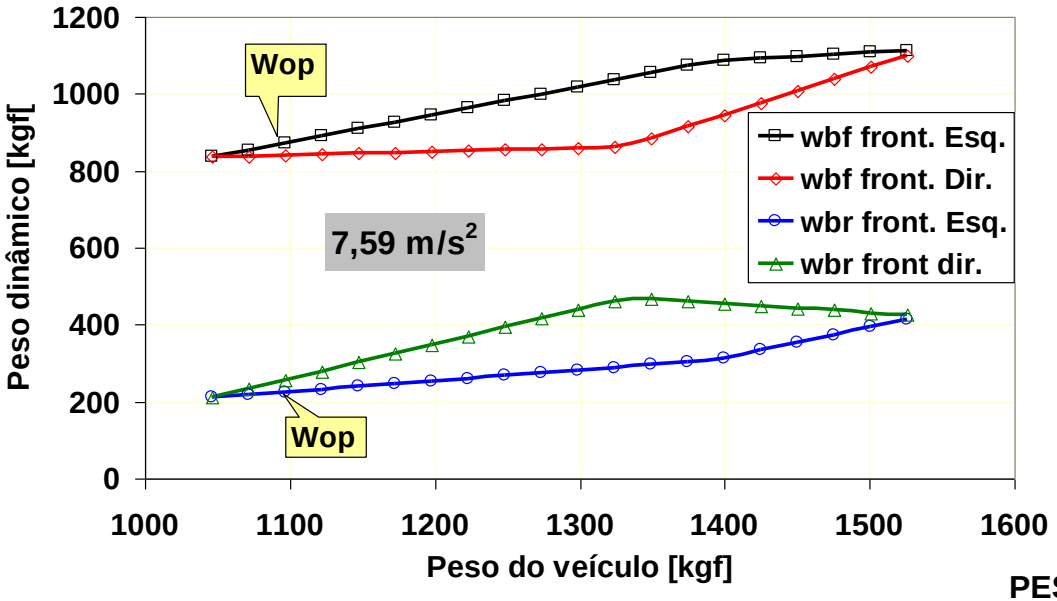


- Passeio do c.g. na transversal (lateral)

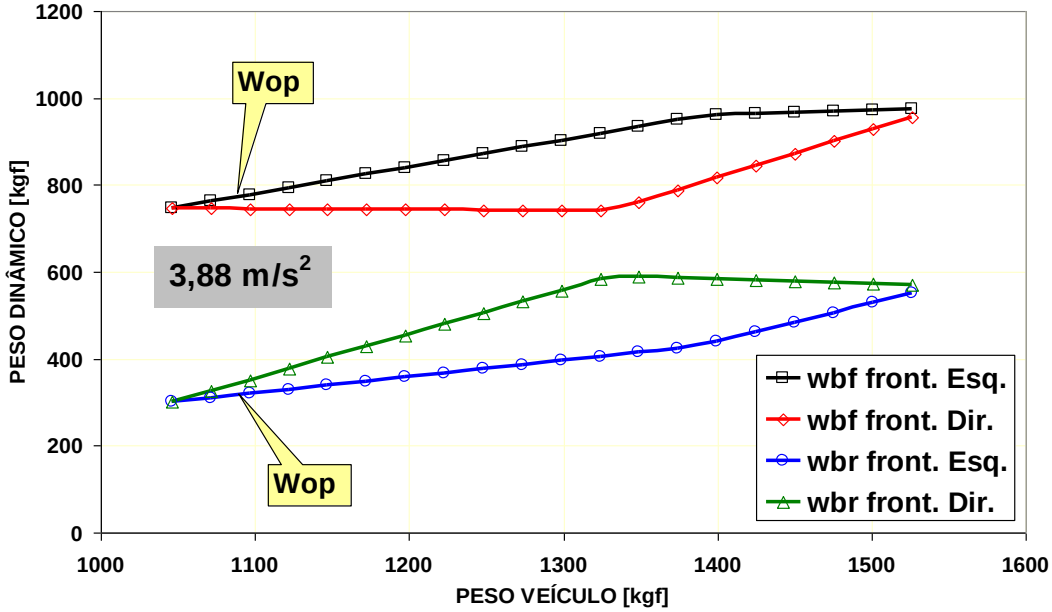

PESO DINÂMICO x PESO DO VEÍCULO - Pista asfalto/concreto - ótimas condições [1,0]
Wop
wbf front. Esq.
wbf front. Dir.
wbr front. Esq.
wbr front. Dir.
W_{bf} - eq. (5.9)
Wbf - eq. (5.10)
onde B + f.w = m.b
(Canale 19890) pag. 82
9,44 m/s²
Wop
Peso dinâmico [kgf]
Peso [kgf]
0
200
400
600
800
1000
1200
1000
1100
1200
1300
1400
1500
1600

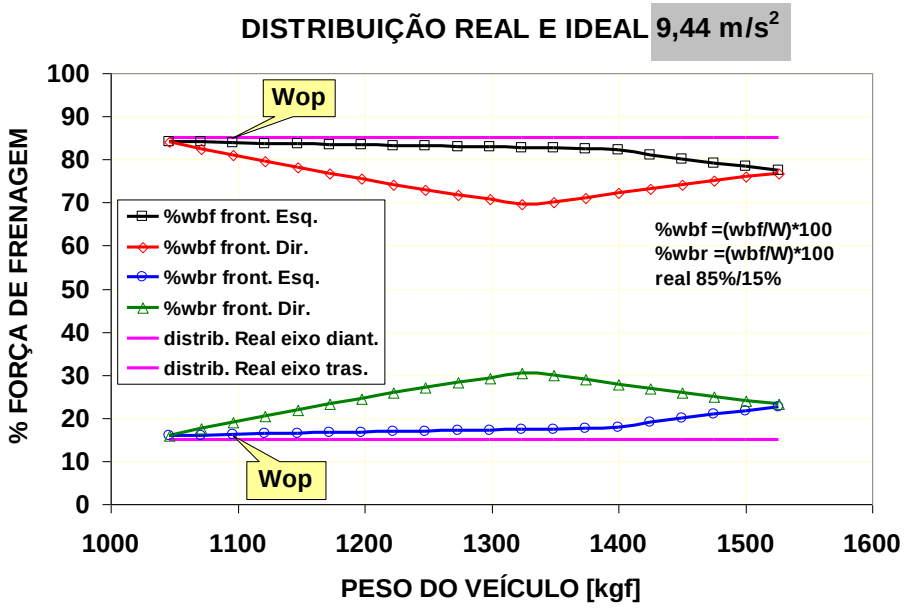

DISTRIBRUIÇÃO ÓTIMA DAS FORÇAS DE FRENAGEM NOS EIXOS DO VEÍCULO
COEFICIENTE DE ADESAO =1,0
84,2
84,0
83,8
83,7
83,5
83,4
83,3
83,1
83,0
82,9
82,8
82,7
82,5
82,5
82,1
81,1
80,1
79,2
78,3
77,4
%WBF4E
%WBF4D
%WBR4E
%WBR4D
% FORCA DE FRENAGEM NOS EIXOS
PESO VEICULO [kGF]
0
10
20
30
40
50
60
70
80
90
100
1000
1100
1200
1300
1400
1500
1600

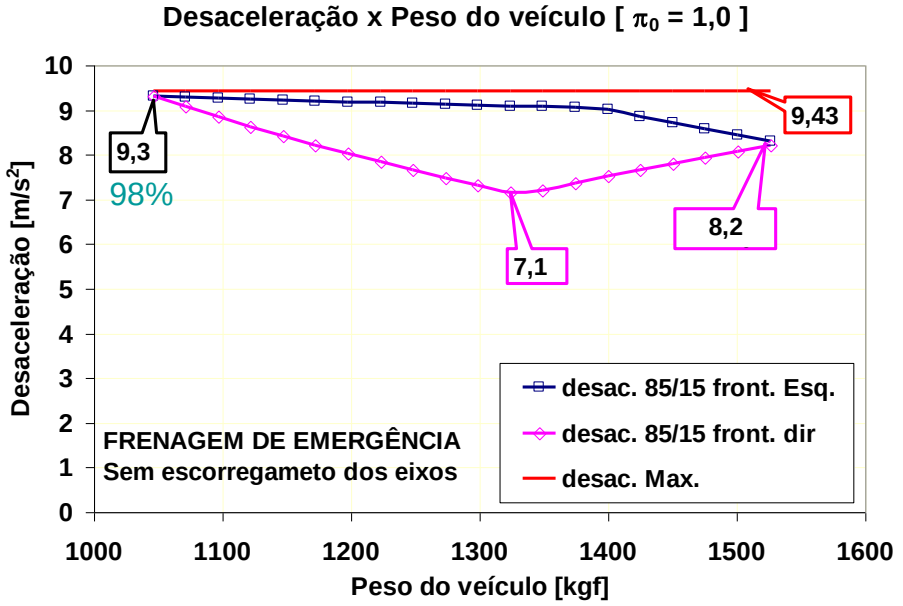
PESO DINÂMICO x PESO DO VEÍCULO - Pista asfalto/concreto - [0,8]

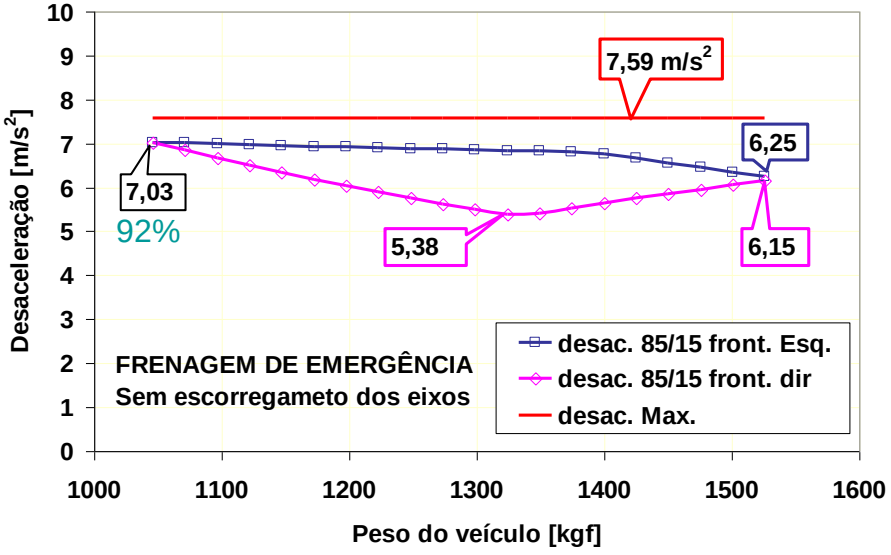


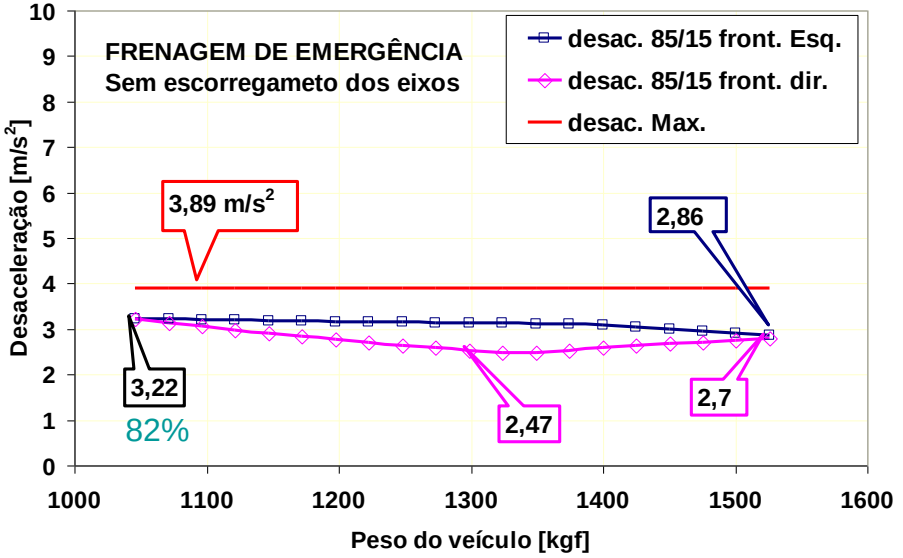
PESO DINÂMICO x PESO DO VEÍCULO [kgf] - pista asfalto/concreto molhada [0,4]

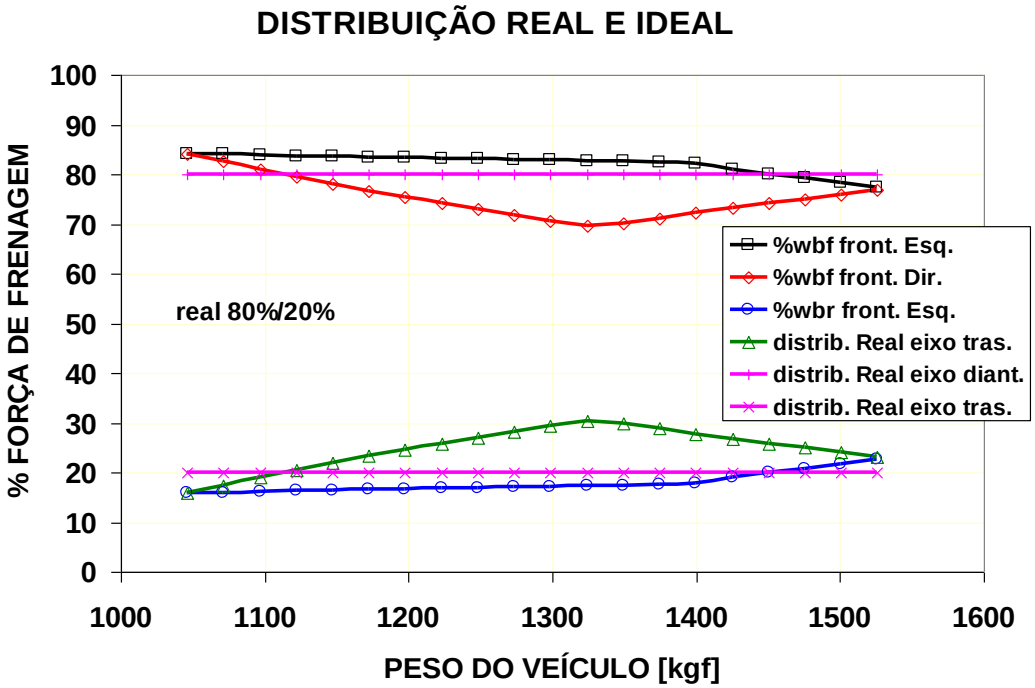


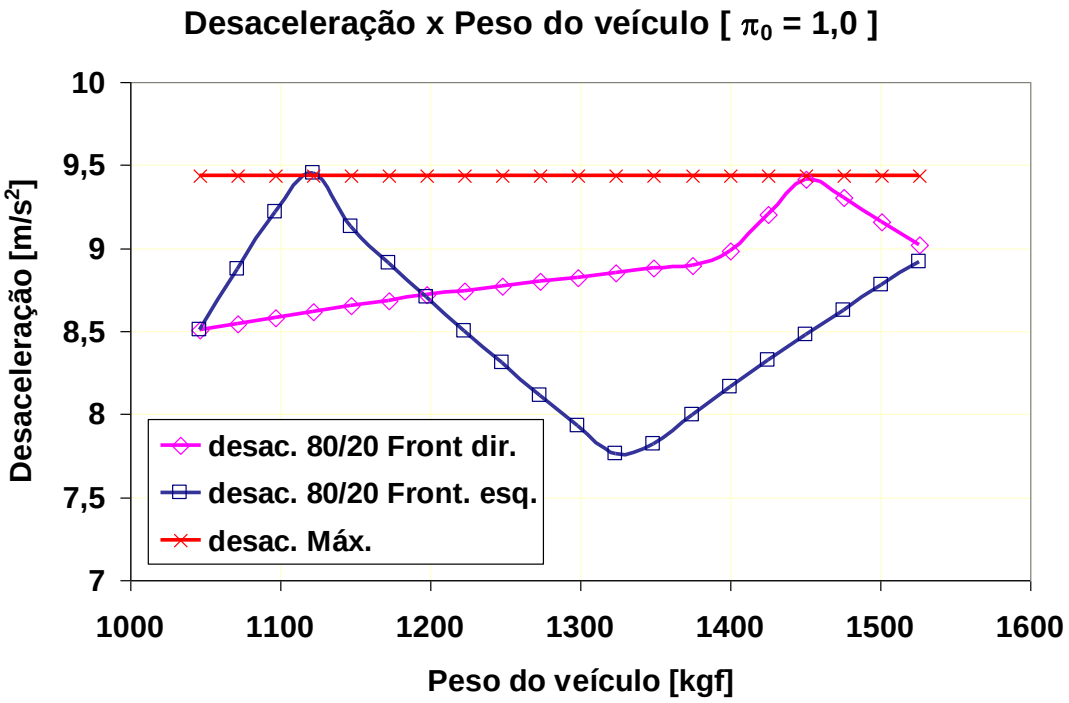

DISTRIBUIÇÃO REAL E IDEAL 9,44 m/s²
Wop
Wop
%wbf front. Esq.
%wbf front. Dir.
%wbr front. Esq.
%wbr front. Dir.
distrib. Real eixo diant.
distrib. Real eixo tras.
%wbf =(wbf/W)*100
%wbr =(wbf/W)*100
real 85%/15%
% FORÇA DE FRENAGEM
PESO DO VEÍCULO [kgf]


Desaceleração x Peso do veículo [π0 = 1,0]
9,3
98%
9,43
8,2
7,1
FRENAGEM DE EMERGÊNCIA
Sem escorregameto dos eixos
desac. 85/15 front. Esq.
desac. 85/15 front. dir
desac. Max.
Desaceleração [m/s²]
Peso do veículo [kgf]

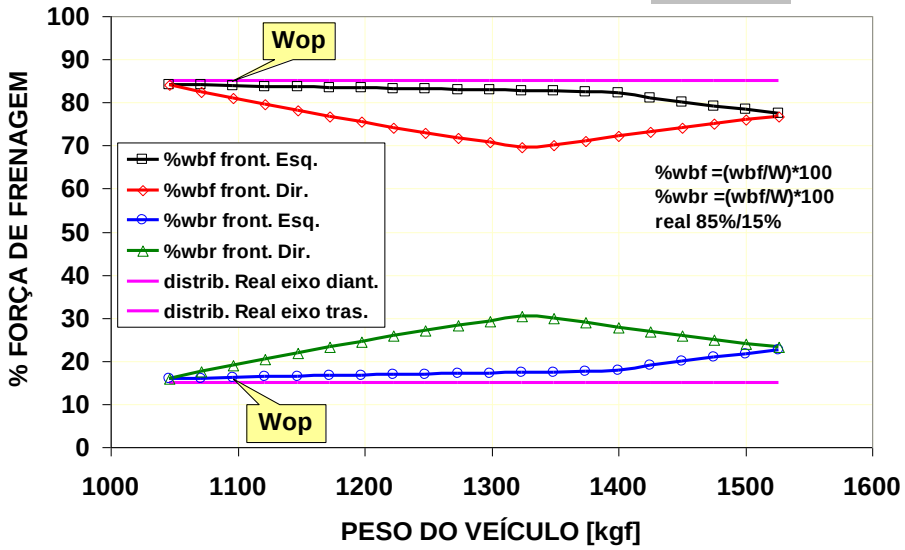

Desaceleração x Peso do veículo [π0 = 0,8]
7,59 m/s²
7,03
92%
6,25
5,38
6,15
FRENAGEM DE EMERGÊNCIA
Sem escorregameto dos eixos
desac. 85/15 front. Esq.
desac. 85/15 front. dir
desac. Max.
Desaceleração [m/s²]
Peso do veículo [kgf]


Desaceleração x Peso do veículo [π0 = 0,4]
FRENAGEM DE EMERGÊNCIA
Sem escorregameto dos eixos
desac. 85/15 front. Esq.
desac. 85/15 front. dir.
desac. Max.
3,89 m/s²
3,22
82%
2,86
2,47
2,7
Desaceleração [m/s²]
Peso do veículo [kgf]

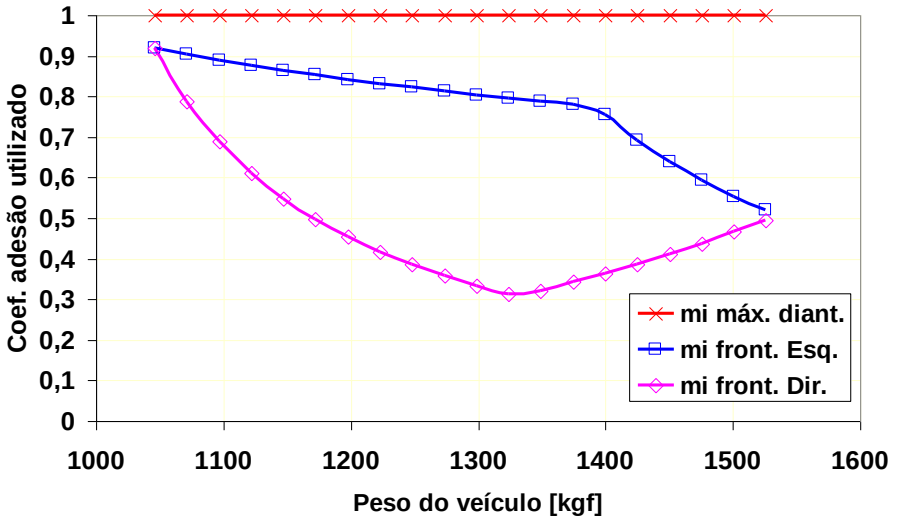

DISTRIBUIÇÃO REAL E IDEAL
% FORÇA DE FRENAGEM
PESO DO VEÍCULO [kgf]
real 80%/20%
%wbf front. Esq.
%wbf front. Dir.
%wbr front. Esq.
distrib. Real eixo tras.
distrib. Real eixo diant.
distrib. Real eixo tras.
100
90
80
70
60
50
40
30
20
10
0
1000
1100
1200
1300
1400
1500
1600


Desaceleração x Peso do veículo [π0 = 1,0]
Desaceleração [m/s2]
Peso do veículo [kgf]
desac. 80/20 Front dir.
desac. 80/20 Front. esq.
desac. Máx.
10
9,5
9
8,5
8
7,5
7
1000
1100
1200
1300
1400
1500
1600

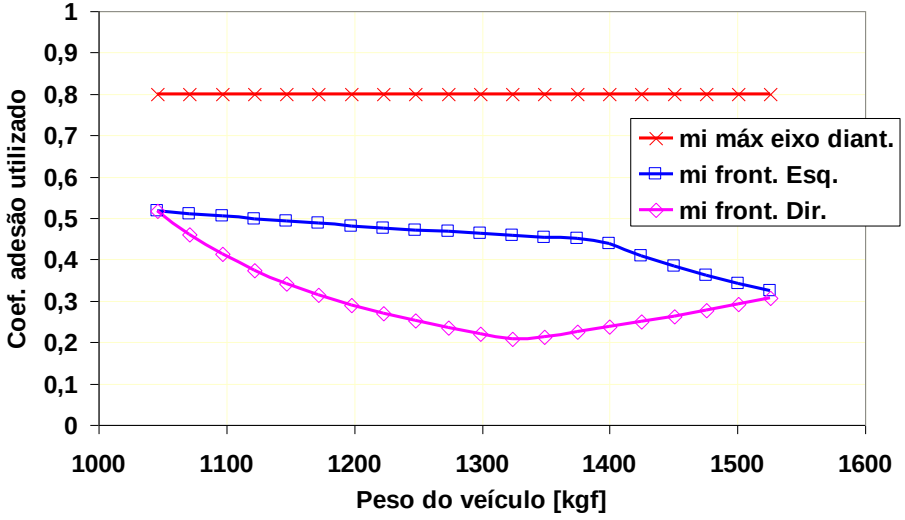
DISTRIBUIÇÃO REAL E IDEAL 9,44 m/s²



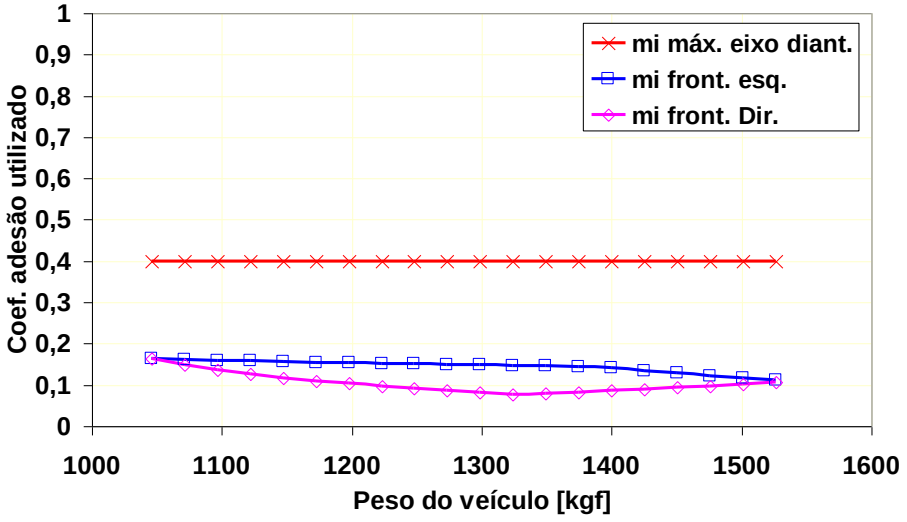
COEFICIENTE DE ADESÃO USADO x PESO DO VEÍCULO [π_0 = 1,0] - 85%/15%



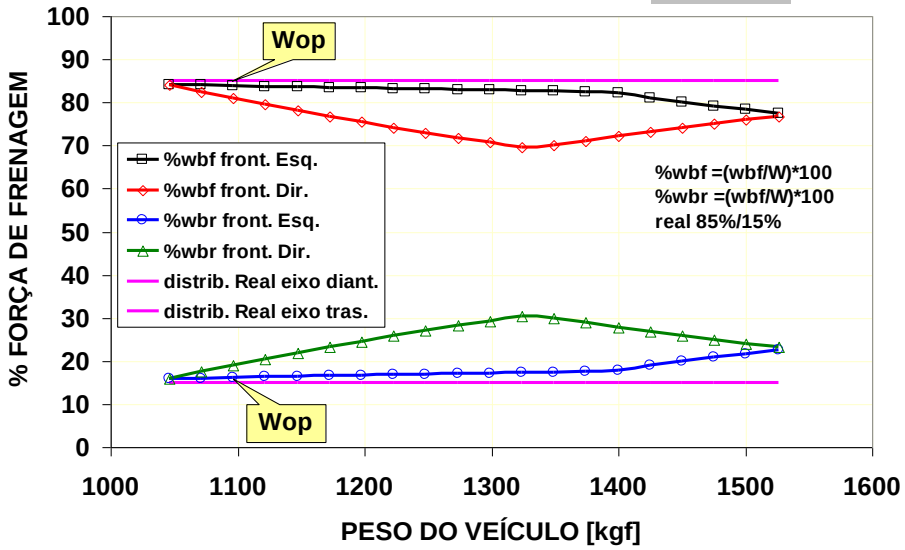
COEFICIENTE DE ADESÃO USADO x PESO DO VEÍCULO [π_0 = 0,8] - 85%/15%



COEFICIENTE DE ADESÃO USADO x PESO DO VEÍCULO [π_0 = 0,4] - 85%/15%

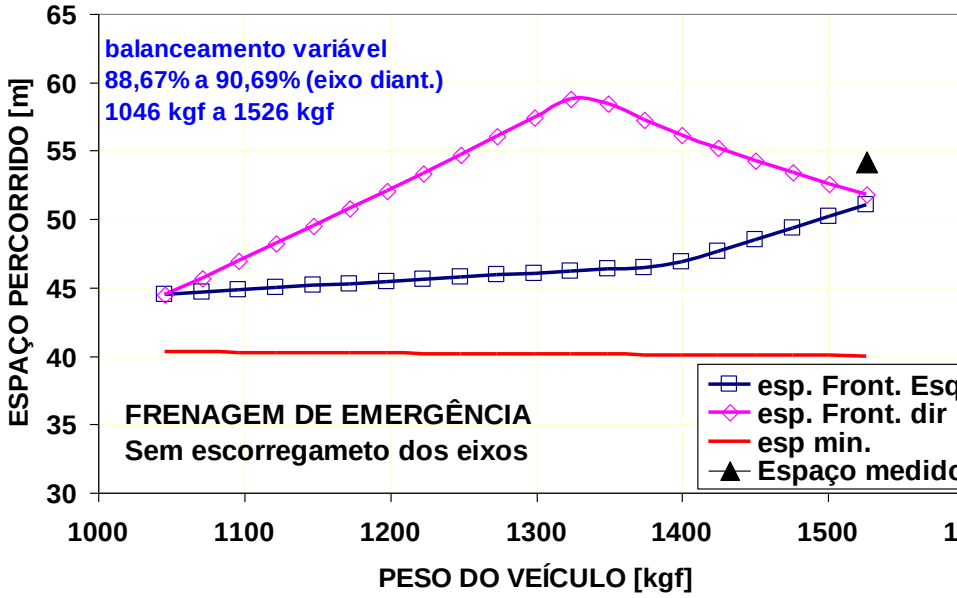


DISTRIBUIÇÃO REAL E IDEAL 9,44 m/s²



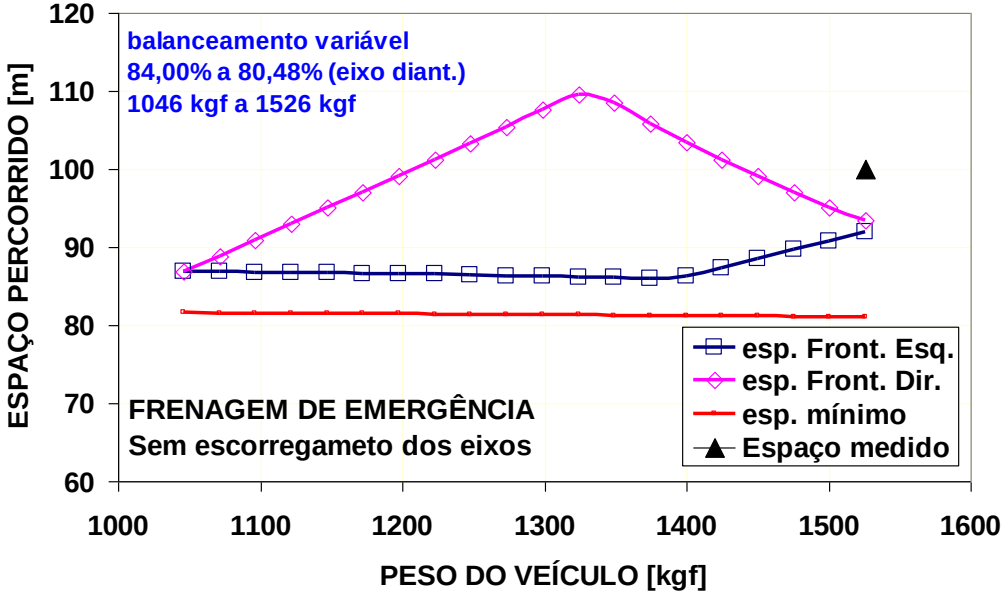
ESPAÇO PERCORRIDO x PESO DO VEÍCULO [π_0 = 0,9]

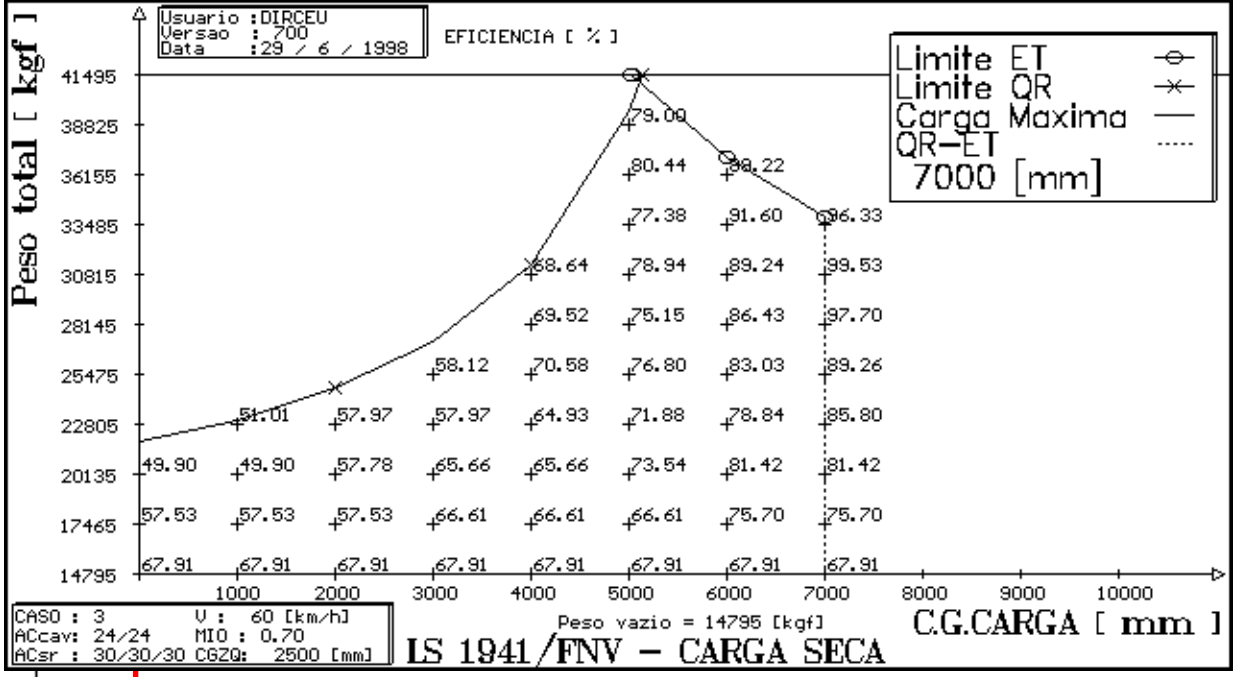
Veloc. inicial 96 km/h

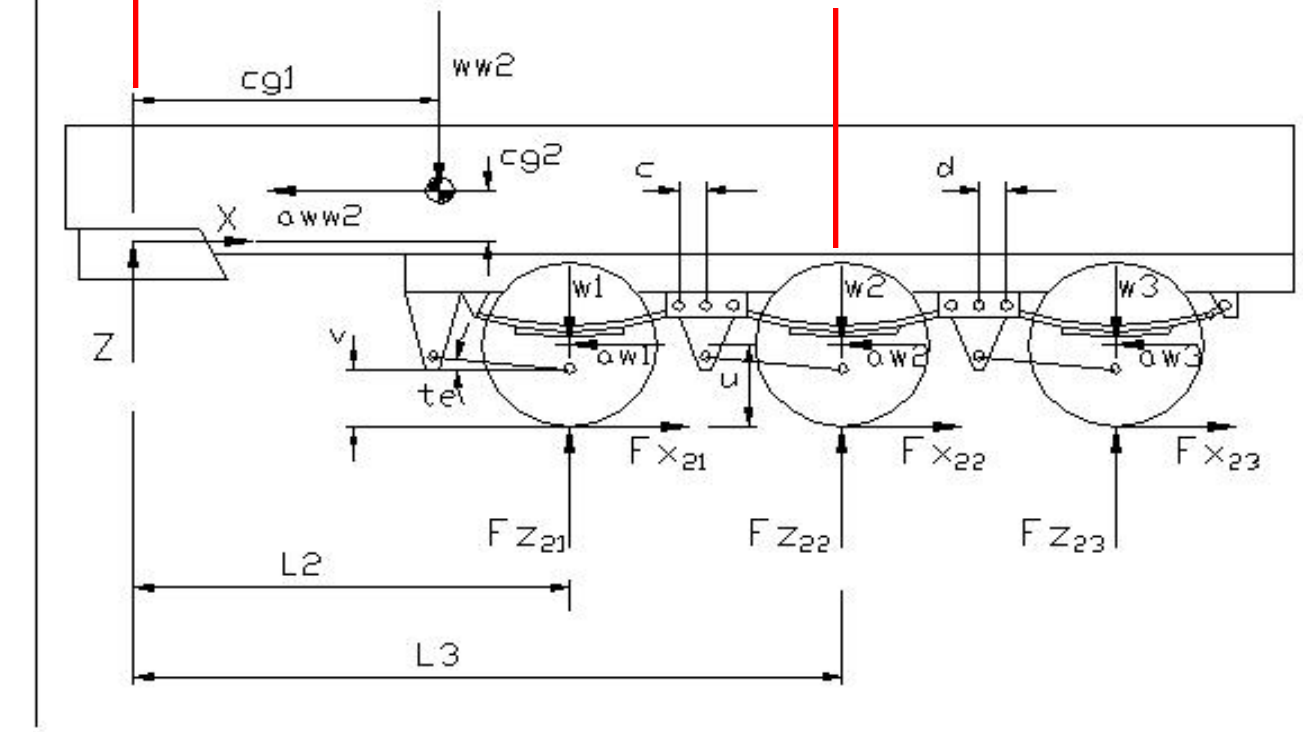


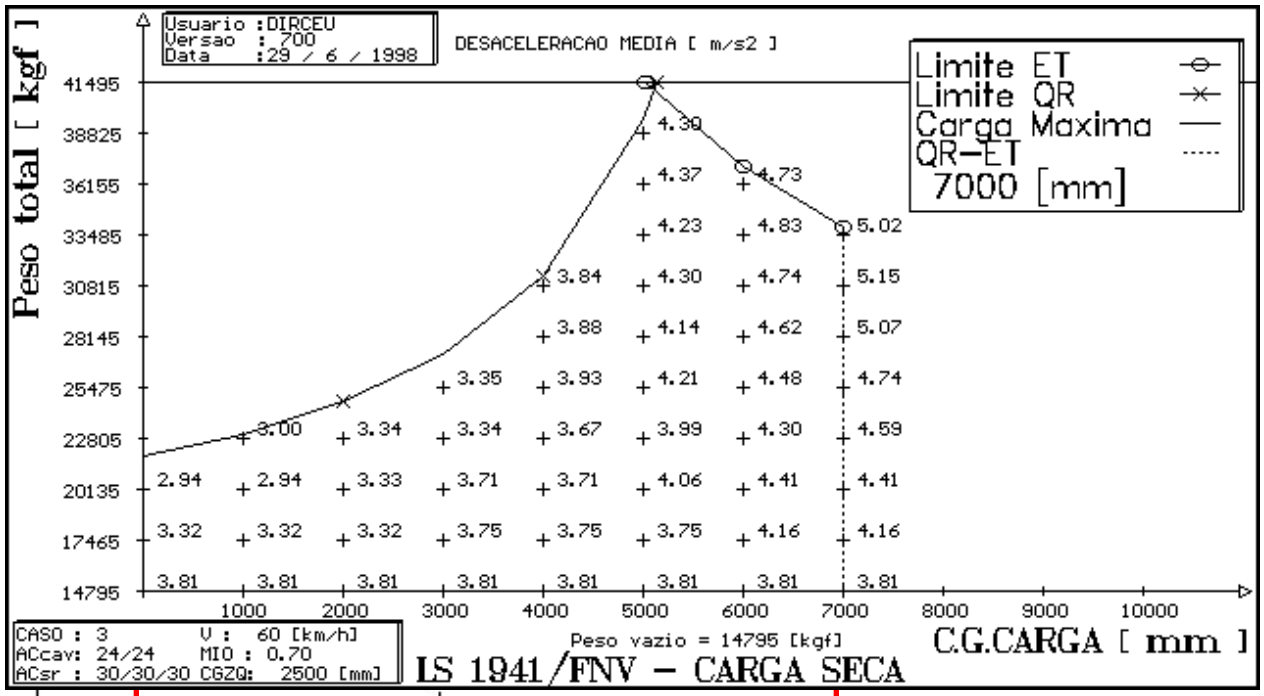
ESPAÇO PERCORRIDO x PESO DO VEÍCULO [π_0 = 0,8]

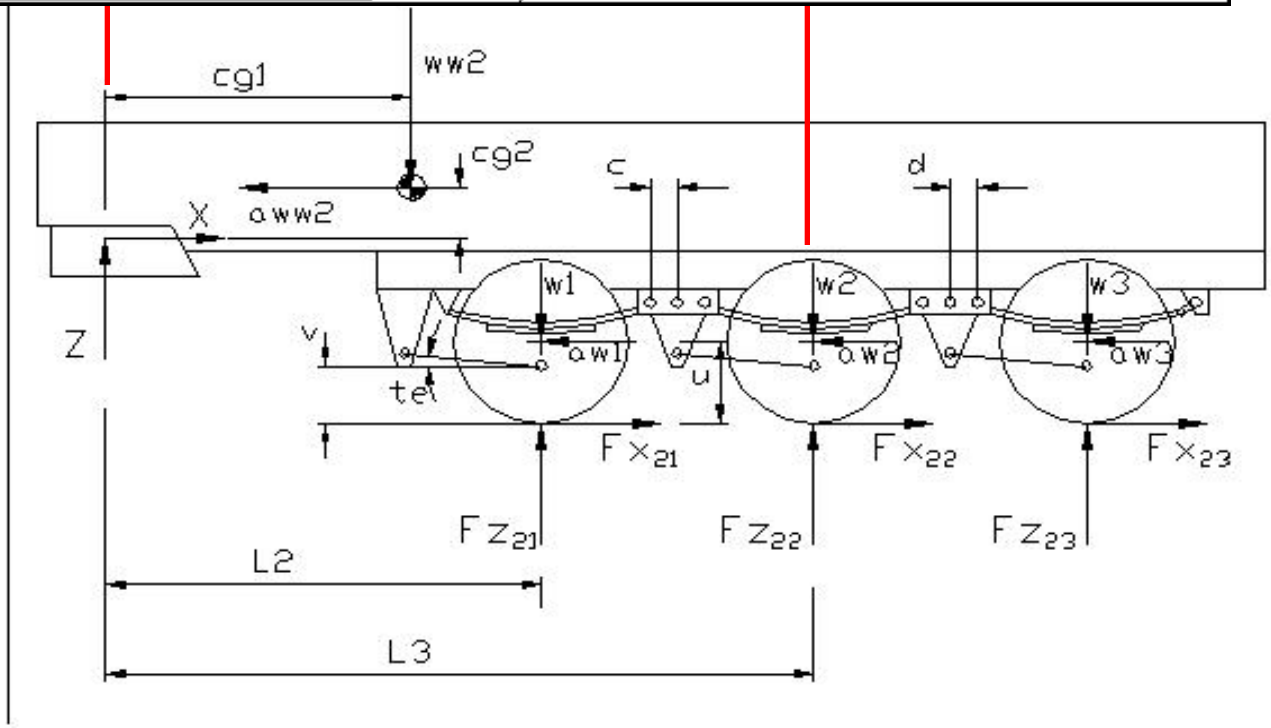
Veloc. inicial 129 km/h

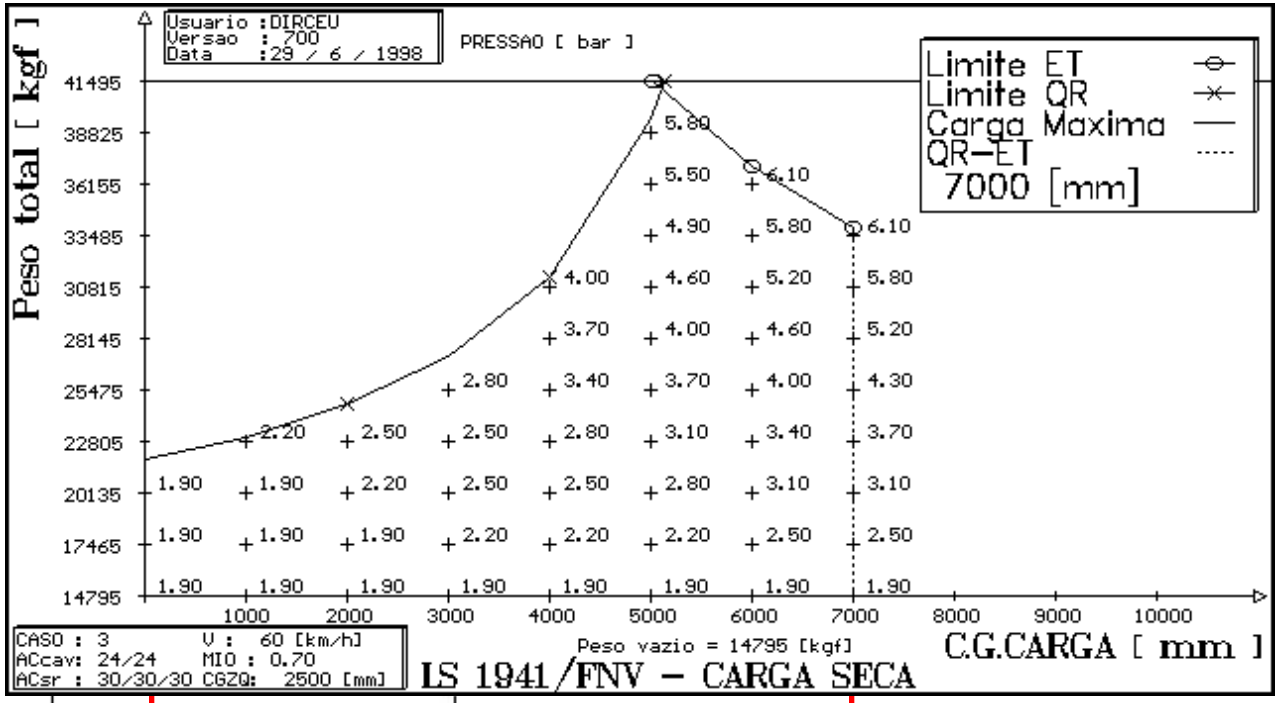


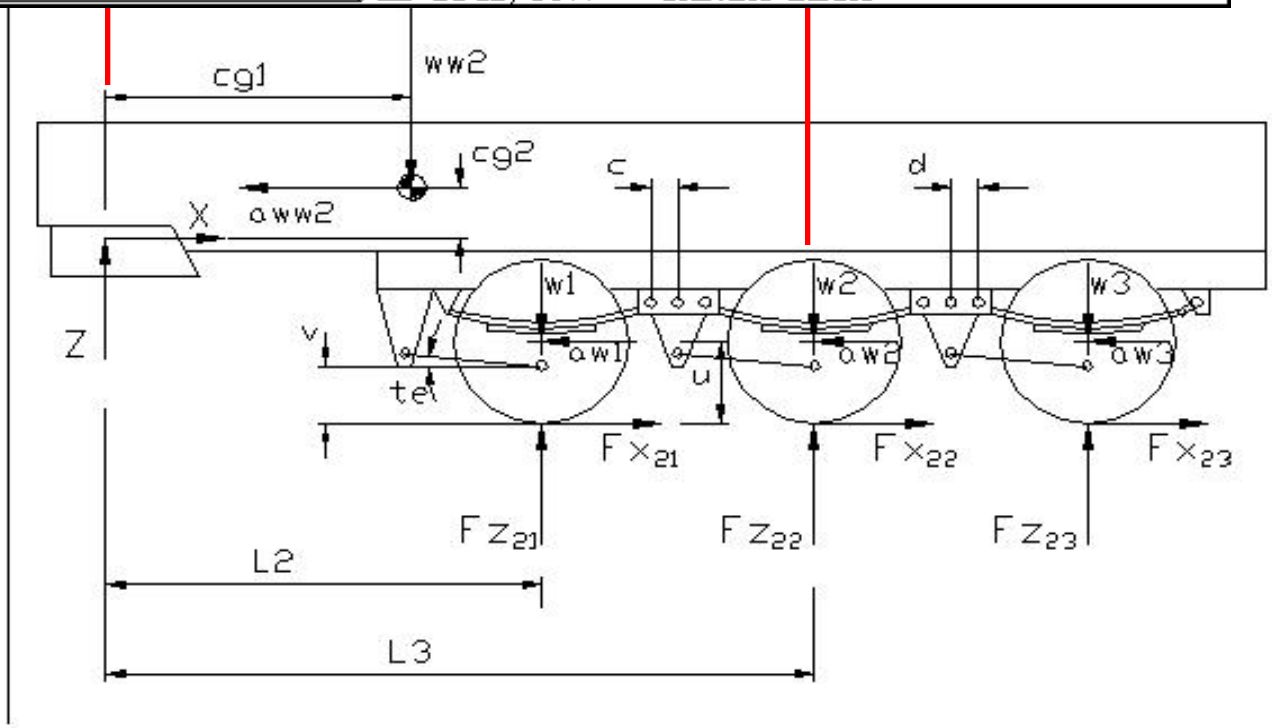

Usuario :DIRCEU
Versao : 700
Data :29 / 6 / 1998
EFICIENCIA [%]
Limite ET
Limite QR
Carga Maxima
QR-ET
7000 [mm]
Peso total [kgf]
41495
38825
36155
33485
30815
28145
25475
22805
20135
17465
14795
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
C.G.CARGA [mm]
Peso vazio = 14795 [kgf]
CASO : 3
V : 60 [km/h]
ACcav: 24/24
MIO : 0.70
ACsr : 30/30/30 CGZ0: 2500 [mm]
LS 1941/FNV - CARGA SECA

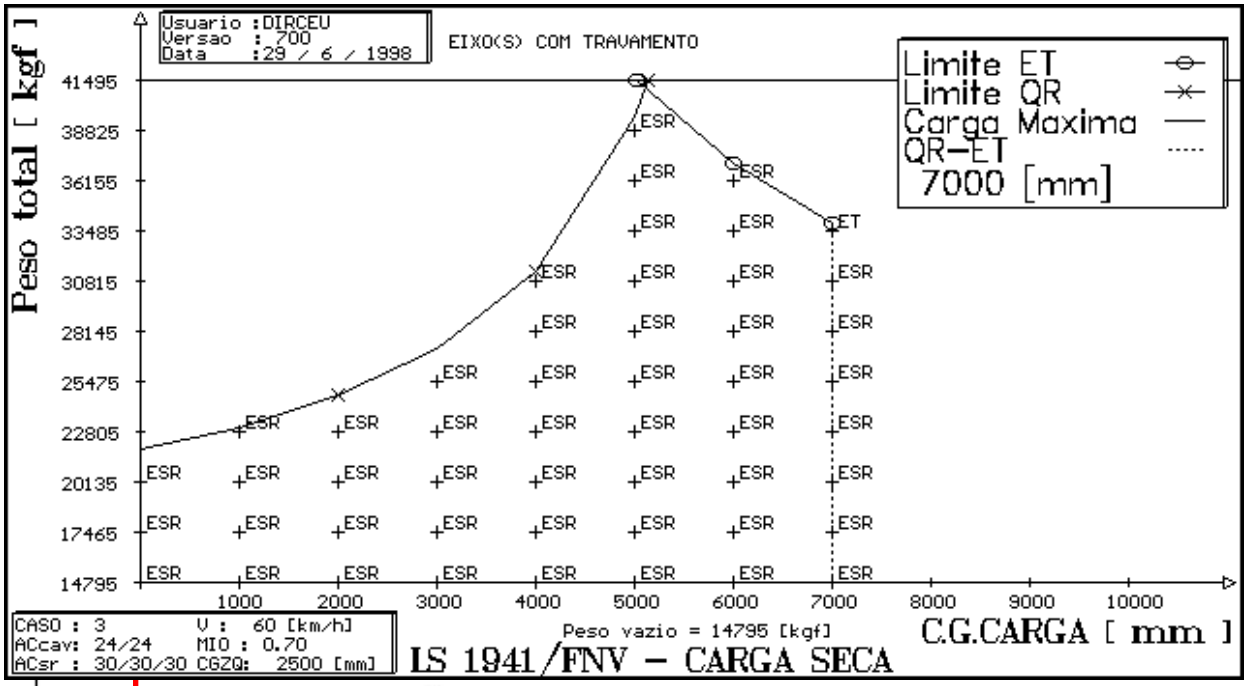

cg1
ww2
cg2
c
d
X
aww2
w1
w2
w3
Z
v
aw1
aw2
aw3
te
u
Fx21
Fx22
Fx23
Fz21
Fz22
Fz23
L2
L3

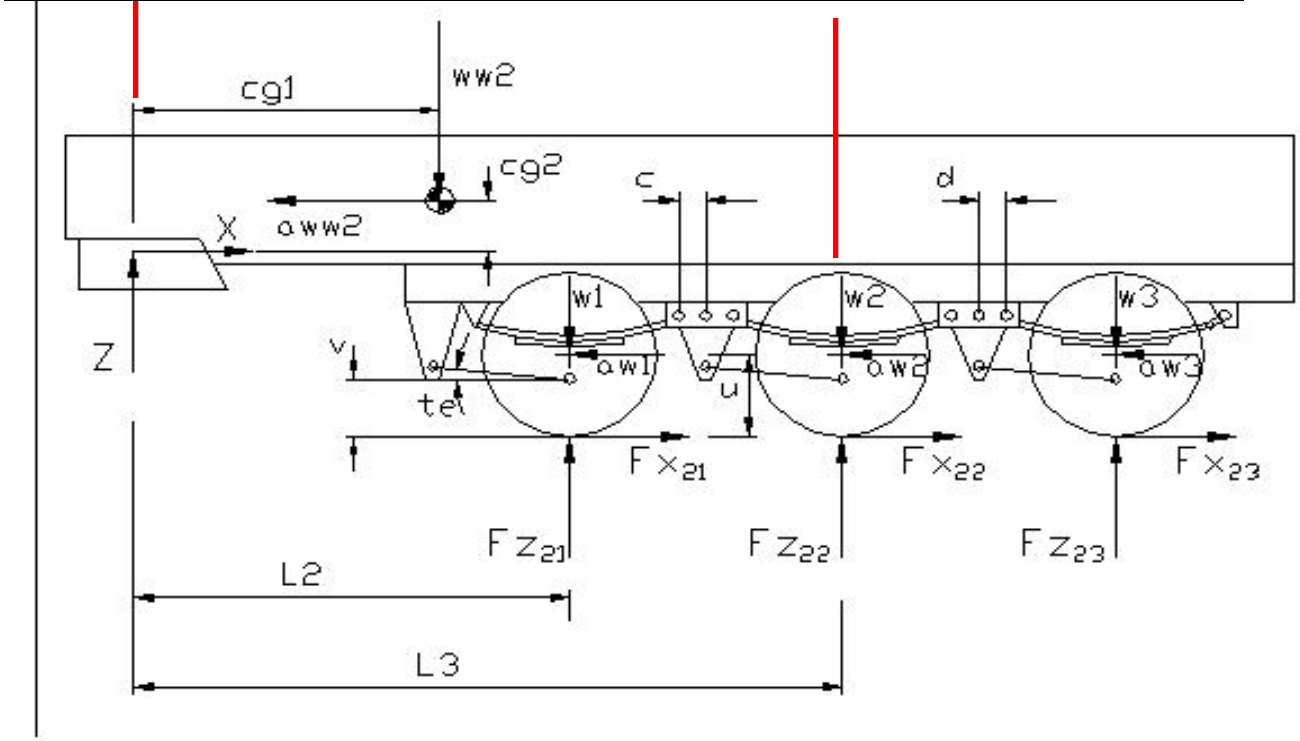

Usuario :DIRCEU
Versao : 700
Data :29 / 6 / 1998
DESACELERACAO MEDIA [m/s2]
Limite ET
Limite QR
Carga Maxima
QR-ET
7000 [mm]
Peso total [kgf]
41495
38825
36155
33485
30815
28145
25475
22805
20135
17465
14795
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
CASO : 3
V : 60 [km/h]
ACcav: 24/24
MIO : 0.70
ACsr : 30/30/30 CGZ0: 2500 [mm]
Peso vazio = 14795 [kgf]
C.G.CARGA [mm]
LS 1941/FNV - CARGA SECA


cg1
ww2
cg2
c
d
X
aww2
w1
w2
w3
Z
v
aw1
aw2
aw3
te
u
Fx21
Fx22
Fx23
Fz21
Fz22
Fz23
L2
L3


Usuario :DIRCEU
Versao : 700
Data :29 / 6 / 1998
PRESSAO [bar]
Peso total [kgf]
Limite ET
Limite QR
Carga Maxima
QR-ET
7000 [mm]
41495
38825
36155
33485
30815
28145
25475
22805
20135
17465
14795
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
CASO : 3
V : 60 [km/h]
ACcav: 24/24
MIO : 0.70
ACsr : 30/30/30 CGZQ: 2500 [mm]
Peso vazio = 14795 [kgf]
C.G.CARGA [mm]
LS 1941/FNV - CARGA SECA


cg1
ww2
cg2
c
d
X
aww2
Z
v
te
w1
w2
w3
aw1
aw2
aw3
u
Fx21
Fx22
Fx23
Fz21
Fz22
Fz23
L2
L3


Usuario :DIRCEU
Versao : 700
Data :29 / 6 / 1998
EIXO(S) COM TRAVAMENTO
Limite ET
Limite QR
Carga Maxima
QR-ET
7000 [mm]
Peso total [kgf]
41495
38825
36155
33485
30815
28145
25475
22805
20135
17465
14795
ESR
ET
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
CASO : 3
ACcav: 24/24
ACsr : 30/30/30
V : 60 [km/h]
MIO : 0.70
CGZQ: 2500 [mm]
Peso vazio = 14795 [kgf]
C.G.CARGA [mm]
LS 1941/FNV - CARGA SECA


cg1
ww2
cg2
c
d
X
aww2
w1
w2
w3
Z
v
te
aw1
aw2
aw3
u
Fx21
Fx22
Fx23
Fz21
Fz22
Fz23
L2
L3