Research Article

Branislav Šarkan*, Marek Jaśkiewicz, and Monika Kiktová

The impact of the truck loads on the braking efficiency assessment

https://doi.org/10.1515/eng-2020-0014
Received Oct 31, 2019; accepted Nov 19, 2019

Abstract: The paper deals with possibilities of assessment of braking efficiency during evaluation of braking system at technical inspection of trucks in conditions of the Slovak Republic. The braking efficiency of the vehicle is evaluated by measuring the braking forces at the roller brake tester. The magnitude of these forces also depends on the loads of the measured vehicle. The paper analyses the results of the practical tests of the braking efficiency measurement of a truck of category N3 and of a vehicle combination consisting of vehicles of category N3 and O4. The analysed vehicle combination was gradually loaded in four different ways and a special situation was the measurement of the braking efficiency of the tractor itself. The instantaneous load on each axle was recorded with portable axle weights. The braking efficiency evaluation was carried out in accordance with the valid methodology, which allows the application of the direct evaluation method, the method of linear extrapolation, the method of the reference braking forces and the indicative evaluation. A vehicle with the same braking system may be assessed as roadworthy or not roadworthy. This is due to the application of different methods of evaluating the braking efficiency and different way of loads at the loading area.

Keywords: braking force, vehicle loads, technical inspection, roller brake tester

***Corresponding Author: Branislav Šarkan:** University of Žilina, Department of Road and Urban Traffic, Univerzitná 8215/1, Žilina 01026, Slovakia; Email: branislav.sarkan@fpedas.uniza.sk
Marek Jaśkiewicz: Kielce University of Technology, Department of Automotive Vehicles and Transportation, al. Tysiąclecia Państwa Polskiego 7; 25-314 Kielce, Poland; Email: m.jaskiewicz@tu.kielce.pl
Monika Kiktová: University of Žilina, Department of Road and Urban Traffic, Univerzitná 8215/1, Žilina 01026, Slovakia

1 Introduction

The braking efficiency is the ability of the brake to reduce the vehicle speed up to a possible stop, to maintain a certain speed of the descending vehicle on a slope, or to keep the vehicle on a slope [1]. When discussing the braking efficiency, it is advisable to distinguish which brake system was built into the vehicle. The construction of the brake system parts depends on its function. Depending on this, the braking is divided into service, parking, emergency, relieving, automatic and inertia. During the technical inspection, the technician not only evaluates the service brake with its functional parts, but also checks the other types of in-vehicle braking systems, if vehicle is equipped with them. These systems differ from each other in terms of construction, therefore the methods of their diagnosis and the expression of the braking efficiency itself also differ. For example, an expression of the efficiency for the service and parking brakes. Both the parking brake and the service brake apply a different method of assessing their suitability.

The brake system inspections of vehicles of categories M1 with a maximum allowed mass exceeding 3.5 tonnes, M2, M3, N2, N3, O3, and O4 are carried out under the conditions of periodic technical inspections on the basis of Methodical Instruction No. 74/2018 in the Slovak Republic. The Regulation lays down the procedure for inspecting these vehicle categories at the roller brake test facilities for the following control items: service brake performance, service brake efficiency, parking brake performance and parking brake efficiency [2, 3].

In order to assess the braking performance of trucks for the purpose of this paper, the performance and efficiency of the service brake were evaluated. The effect of the service brake is expressed in the Methodical Instruction No. 74/2018 [1] by braking ratio. The braking ratio is the ratio of the sum of the braking forces attained for a particular type of braking and the gravity of the tested vehicle. Braking ratio is expressed as a percentage. This methodical instruction also sets the minimum braking ratio value for specific vehicle categories depending on the date of first registration or the date of their approval and also

Table 1: The values of prescribed minimum braking ratios. Source: [1]

Vehicle category	Minimal Braking ratio Z_{min} (%)	
	Vehicles registered for the first time since 1.1.2012	Vehicles registered for the first time before 1.1.2012
N1	50%	40%
M1	58%	50% and for vehicles without ABS or approved before 1.10.1991 48%
M2 a M3	50%	50% and for vehicles without ABS or approved before 1.10.1991 48%
N2 a N3	50%	for vehicles registered for the first time after 1988 45% and for others 43%
O2, O3 a O4	45% for semi-trailers, 50% for drawbar trailers	for semi-trailers and drawbar trailers registered for the first time after 1988 and 40% for others

the presence of the ABS system. Vehicles of categories L, M, N, O, T, R and Ps shall be capable of attaining the prescribed minimum braking efficiency in terms of braking ratio with the service brake. The values of prescribed minimum braking ratios are given in Table 1 [1, 4].

2 The methodology of assessing the service brake efficiency

The procedure for evaluating the braking efficiency of the truck's service brake shall be determined according to the construction of the vehicle's brake system, the vehicle's control connections and the available brake system data. In the case of trucks there is a pneumatic system and therefore we can follow all four available methods of evaluating the braking performance: Direct evaluation method, Reference forces method, Linear extrapolation method, Indicative evaluation method [5, 6].

2.1 Direct evaluation method

The method is based on a direct evaluation of the braking efficiency of the vehicle without measuring the control air pressure or brake pressure. The braking efficiency is obtained on the basis of the braking ratio calculated from the braking forces measured on the roller brake tester on a partially or fully loaded vehicle [5, 7–9].

The braking forces measured at the roller brake tester shall be used to calculate the braking ratio according Equation (1) that the vehicle would have achieved under the same braking forces under load conditions at the maximum permissible gross mass:

$$Z = 10,2 \cdot \frac{\sum B_{vi}}{m_c} \tag{1}$$

where:
Z - braking ratio [%],
ΣB_{vi} - sum of the braking forces at the circumference of the axle wheels i [N],
m_c - maximum permissible gross mass of the vehicle [kg] [1, 8, 10].

2.2 Reference forces method

The method is based on evaluating the braking efficiency of the vehicle by comparing the achieved braking forces at a defined braking pressure on all wheels of the vehicle with the reference braking forces data specified by the vehicle manufacturer. This method may only be used if the necessary brake system data (reference braking forces) are available and the vehicle is equipped with functional control brake pressure connections [9, 11–13].

On each axle of the vehicle, the sum of the measured braking forces on each wheel is compared with the corresponding reference braking force according Equation (2). If for each axle of the vehicle meet:

$$\sum B_{vi} \geq \sum B_{vi} \tag{2}$$

then the service brake of the vehicle achieves the prescribed minimum braking efficiency [1, 10, 14, 15].

At the time of the measurement, the technical inspection's information system of did not provide Volvo brake reference force data or Schwarzmuller reference brake force data. That is why it was not possible to use this method to evaluate the braking efficiency of the semi-trailer vehicle combination.

2.3 Linear Extrapolation method

This method is based on the evaluation of the dependence of the braking forces measured on roller brake tester from the braking pressure measured through the control connections. The extrapolation is applied to a theoretical condition corresponding to the minimum air pressure in the service brake system with the brake pedal fully depressed and with vehicle which is loaded to the maximum permissible total mass. In the case of a trailer inspection, the towing vehicle to which it is coupled in the combination shall be capable of at least the pressure values prescribed by the trailer's manufacturer in the charging and control lives (generally at least 800 kPa in the charging line and at least 650 kPa in control line).

From the braking pressure values measured on the roller brake tester, an extrapolation constant ii is calculated for each axle of the vehicle separately according Equation (3):

$$i_i = \frac{p_{mci} - p_{ni}}{p_i - p_{ni}}. \quad (3)$$

where:
p_{mci} - minimum service brake circuit pressure on the axle i at full depressed brake pedal of the vehicle loaded to the maximum permissible gross weight (kPa). If this is not known, a p_{mci} value of 800 kPa shall be used for each axle of the motor vehicle. In the case of a trailer, a p_{mci} of 650 kPa shall be used for each axle,
p_{ni} - pressure at the beginning of braking applied of the axle i (kPa); if the beginning of braking applied pressure value cannot be unambiguously determined during the measurement, a constant value of 40 kPa shall be used for the calculation.
pi - braking pressure at which the maximum braking forces on the axle i in (kPa) have been achieved on the roller brake tester [1, 6, 16–18].

The values measured on the roller brake tester and the extrapolation constants of all axles are used to calculate the vehicle braking ratio. This braking ratio is extrapolated to the theoretical state corresponding to the minimum braking pressure when the brake pedal is fully depressed, and the vehicle is loaded for the maximum permissible gross mass according to the Equation (4):

$$Z = 10,2\frac{\sum B_{V_1 \cdot i_1} + \sum B_{V_2 \cdot i_2} + \cdots + \sum B_{V_n \cdot i_n}}{m_c} \quad (4)$$

where:
Z - braking ratio [%],
ΣB_{vi} - sum of the braking forces at the circumference of the axle wheels i [N],
ii - extrapolation constants of the axle i,
m_c - maximum permissible gross mass of the vehicle [kg] [1].

2.4 Indicative Evaluation method

The method is based on evaluating the braking performance of a vehicle by achieving all-wheel lock when measuring braking forces on a partially or fully loaded vehicle on a roller brake tester. This method can only be used if the vehicle being inspected is not equipped with brake pressure control connections or if the vehicle's pressure control connections are not functional and other methods described in this Guideline cannot be used (*e.g.* due to unavailability of inspected vehicle's brake technical data). Using the method with reduced friction coefficient of roller brake tester cylinders surface (*e.g.* wet) can lead to incorrect vehicle evaluation. The evaluation using this method is only indicative in comparison with the above methods and corresponds only to the instantaneous load condition of the vehicle [19–21].

This method is inapplicable in both cases of the vehicles tested, as they are subject to the obligation to be fitted with control pressure connections as they are registered for the first time after 31.12.1994 [2, 13, 22].

3 Measurement procedure and braking efficiency results

The analysis of the service brake efficiency was performed on a Volvo FH 460 N3 tractor and a Schwarzmüller SPA / 3EE O4 semi-trailer. The measurements were carried out at the Station of Technical Inspection in Kysucké Nové Mesto. The MAHA Eurosystem LKW IW 4 LON measuring device is used to measure the service brake efficiency in a given Station of Technical Inspection. The decisive factor in measuring the braking efficiency was the load on the vehicle by different load distribution variants. We simulated real performance at the Station of Technical Inspection according to generally binding and valid methodologies. When measuring the load on the individual axles of the vehicle, we used portable scales of the brand Tenzováhy type PV-10. It is a system used for control weighing by both state au-

Table 2: The measured load of individual axles.

	Tractor load [kg]		Semi-trailer load [kg]		
	1. axle	2. axle	1. axle	2. axle	3. axle
1. measurement	7 200	10 200	6 750	7 000	7 500
2. measurement	7 350	10 700	2 700	2 900	3 000
3. measurement	5 450	2 450	6 850	7 350	8 150
4. measurement	5 700	3 350	1 550	1 750	1 950
5. measurement	5 500	2 500	-	-	-

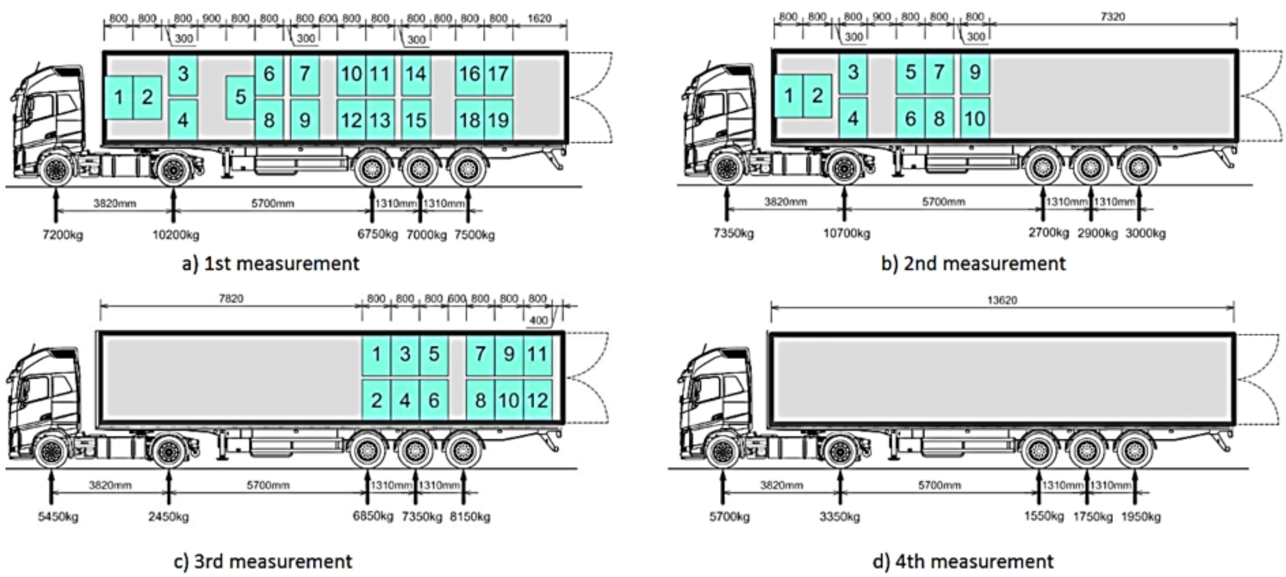

Figure 1: Load distributions: a) Measurement No. 1; b) Measurement No. 2; c) Measurement No. 3; Measurement No. 4.

thorities and private companies. The portable scales can be used in both static and dynamic mode (while driving).

The following load variants of the vehicle combination were simulated:

– Measurement No.1 - Maximum semi-trailer load,
– Measurement No.2 - Load of the front part of the semi-trailer,
– Measurement No.3 - Load of the rear part of the semi-trailer,
– Measurement No.4 - Unloaded semi-trailer,
– Measurement No.5 - Tractor without semi-trailer.

The load on the individual axles varied depending on how the goods were distributed in the loading area of the semi-trailer. The goods consisted of pallet units with the same weight of approximately 1.33 tons. The load of individual axles of tractor and semi-trailer measured by axle scales PV-10 are processed in Table 2.

Four load distributions on the semi-trailer simulate four different cases of load distribution on the loading area. In Figure 1(a, b, c, d) are shown the distribution of pallet units in semi-trailer. In the case of Figure 1d is an unloaded semi-trailer and a special case is Measurement No.5, in which the tractor without an attached semi-trailer was evaluated.

4 Service brake efficiency results

Table 3 lists all relevant data measured at the roller brake tester. These data are necessary to calculate the service brake efficiency by available methods. To calculate the braking ratio by linear extrapolation, the construction pressures data of the braking actuator have also been added. When calculating the brake ratio by direct evaluation and linear extrapolation, it is also necessary to know the values of the maximum gross weights of the vehicles, which are 18 000 kg for the tractor and 27 000 kg for the semi-trailer. The table contains all available information necessary for evaluating the braking efficiency of the vehicle at the roller brake tester. It is the braking force on the in-

Table 3: Results for all measurements of service brake efficiency.

Vehicle	Axle	Braking force for service brake (kN)		Braking pressure (kPa)	Construction pressure of the braking actuator (kPa)	Symmetry (%)	Comply	Variation of braking force (%)		Comply
Measurement No.1										
Tractor	1	23.87 N	22.29 B	510	1000	10	Y	4	6	Y
	2	23.49 N	23.31 B	460	1000	9	Y	12	7	Y
Semi-trailer	1	12.40 N	15.00 B	444	650	23	Y	6	9	Y
	2	14.24 B	14.78 N	458	650	4	Y	8	5	Y
	3	17.85 B	16.75 N	520	650	6	Y	7	6	Y
Measurement No.2										
Tractor	1	24.71 N	23.07 B	502	1000	8	Y	7	6	Y
	2	23.77 N	23.51 B	362	1000	14	Y	10	10	Y
Semi-trailer	1	4.52 N	4.31 B	170	650	31	N	44	64	N
	2	5.04 B	6.30 N	186	650	25	Y	18	11	Y
	3	5.62 B	6.44 N	74	650	20	Y	18	11	Y
Measurement No.3										
Tractor	1	20.22 N	19.00 B	414	1000	13	Y	8	7	Y
	2	7.69 B	8.11 N	520	1000	15	Y	20	13	Y
Semi-trailer	1	11.90 N	14.46 B	390	650	22	Y	8	8	Y
	2	14.71 N	15.20 B	488	650	17	Y	9	4	Y
	3	18.92 B	17.65 N	500	650	17	Y	6	7	Y
Measurement No.4										
Tractor	1	21.08 B	19.26N	434	1000	14	Y	7	4	Y
	2	12.12 N	11.89 B	494	1000	16	Y	20	8	Y
Semi-trailer	1	1.69 N	2.57 B	88	650	49	N	12	11	Y
	2	2.91 B	3.05 N	102	650	38	N	17	5	Y
	3	4.0 N	4.67 B	62	650	14	Y	12	56	N
Measurement No.5										
Tractor	1	18.18 N	15.7 B	258	1000	14	Y	5	9	Y
	2	8.01 B	7.89 N	508	1000	14	Y	15	14	Y

Table 4: The comparison of Direct evaluation method and Linear extrapolation method.

Vehicle	Measurement No.	Required braking ratio Z (%)	Direct evaluation method			Linear extrapolation Method			
			Total weight of vehicle from the Certificate of Registration (kg)	Result (%)	Comply	Total weight of vehicle from the Certificate of Registration (kg)	Result (%)	Comply	Requirement of 30% Pm
tractor	1	50	18 000	52.68	yes	18 000	114.04	yes	yes
	2	50	18 000	53.87	yes	18 000	136.13	yes	yes
	3	50	18 000	31.18	no	18 000	74.95	yes	yes
	4	50	18 000	36.47	no	18 000	84.47	yes	yes
	5	50	18 000	28.21	no	18 000	103.02		no
semi-trailer	1	45	27 000	34.39	no	27 000	48.24	yes	yes
	2	45	27 000	12.18	no	27 000	115.29		no
	3	45	27 000	35.07	no	27 000	51.06	yes	yes
	4	45	27 000	7.14	no	27 000	133.42		no

dividual axles, the control pressure in the air pressure system, the symmetry of the braking efficiency and the variation of braking efficiency. The results of the achieved braking forces and the control pressure are further converted into a vehicle braking ratio parameter, depending on the vehicle load, according to the mentioned methods for evaluating the braking efficiency of heavy duty vehicles. Table 3 shows that incorrect axle load or low axle load also has a significant effect on the symmetry of braking efficiency and variation of braking efficiency [6, 23, 24]. The symmetry of the braking efficiency shall not exceed 30% for each axle, which is not observed in the case of measurements No.2 and No.4 for the evaluation of the axles of the semi-trailer. The variation in braking efficiency shall not exceed 10%. The variation in braking performance shall not exceed 10%. This value was also exceeded in case of measurement No.4 for the third axle of the semi-trailer because of unloaded semi-trailer. A vehicle so loaded when measuring the service brake efficiency during a periodic technical inspection would be assessed as not roadworthy [1, 16, 25].

The values given in Table 4 are obtained after calculating the braking ratio by all available methods of evaluating the service braking efficiency. The table contains the required braking ratio values for tested vehicles, the total and instantaneous masses of vehicles used in calculating as well as the vehicles roadworthy [18]. A total of up to 3 cases of evaluation could not use the linear extrapolation method because the condition for reaching 30% of the construction pressure of the braking actuator was not met.

Although there are several methods available for evaluating the braking efficiency of a service brake, they do not always lead to the same evaluation, even if it is one and the same vehicle. The load factor appears to be very important. Direct evaluation method is only applicable in a small percentage of cases, although it remains the most physically accurate method. This is due to the fact that the vehicles are under-loaded to the technical inspection. The reference braking forces are not provided by the manufacturers in the extent that they could cover the full range of tested vehicles. In terms of evaluating the service brake efficiency, the indicative evaluation method is the least accurate evaluation method for new vehicles. Therefore, it is only used for older vehicles. With regard to linear extrapolation method, it is accepted as a full-fledged method, although the braking effect calculated on the basis of this method is only theoretical.

In Figure 2 there is shown which axles meet the condition of reaching 30% of the construction pressure of the brake actuator and which do not. The red dashed line is a separate area showing the satisfactory and unsatisfactory control pressure values for use in the extrapolation calculation of braking ratio for the Volvo N3 tested vehicle. For this vehicle we assume a value of P_m = 10 bar (manufacturer's data) and from this value the result is P_{min} = 0.3 x P_m = 3 bar.

In Figure 3 it is shown which axles meet the condition of reaching 30% of the construction pressure of the brake actuator and which do not. Colour numbers of the measurements are distinguished for a better overview. There are also areas showing satisfactory and unsatisfactory control pressure values for use in the extrapolation calculation of braking ratio for the Schwarzmuller O4 tested vehicle. For this vehicle we assume a value of Pm = 6.5 bar (manufacturer's data) and from this value the result is P_{min} = 0.3 × P_m = 1.95 bar.

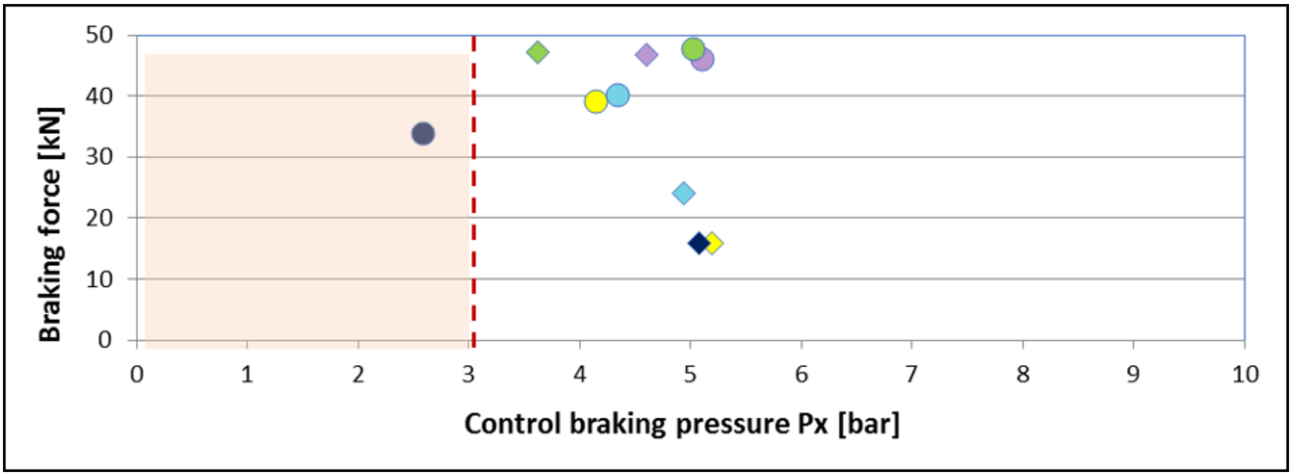

Figure 2: Dependence of braking forces on tractor control pressure.

● measurement No. 1, axle 1 ● measurement No. 3, axle 1 ● measurement No. 5, axle 1 ● measurement No. 2, axle 1
◆ measurement No. 1, axle 2 ◆ measurement No. 3, axle 2 ◆ measurement No. 5, axle 2 ◆ measurement No. 2, axle 2
● measurement No. 4, axle 1
◆ measurement No. 4, axle 2

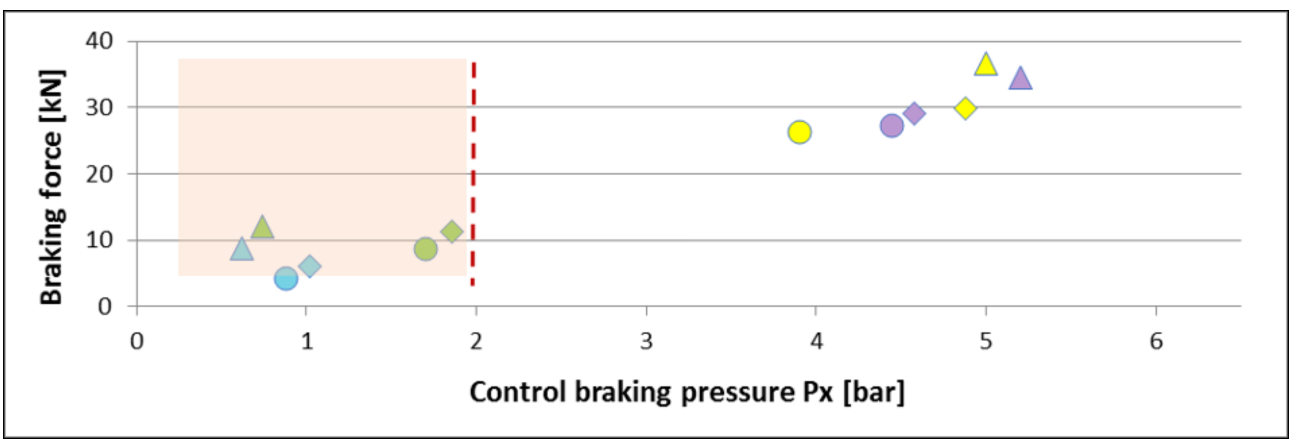

Figure 3: Dependence of braking forces on control pressure for semi-trailer.

● measurement No. 1, axle 1 ● measurement No. 3, axle 1 ● measurement No. 2, axle 1 ● measurement No. 4, axle 1
◆ measurement No. 1, axle 2 ◆ measurement No. 3, axle 2 ◆ measurement No. 2, axle 2 ◆ measurement No. 4, axle 2
▲ measurement No. 1, axle 3 ▲ measurement No. 3, axle 3 ▲ measurement No. 2, axle 3 ▲ measurement No. 4, axle 3

5 Conclusion

The evaluation of the braking efficiency at the roller brake tester can be considered as the most important check within the regular technical inspection of both passenger cars and trucks. The results are the output of practical measurements of the semi-trailer vehicle combination with different loads at a particular Station of Technical Inspection. Over the past seven years, a specific technical inspection worker has carried out 343 periodic technical inspections of vehicle categories N2 and N3 and 129 technical inspections of vehicle categories O3 and O4. Of the 343 checked vehicles, 44 vehicles were assessed as unfit for braking efficiency, 21 of which were obviously due to insufficient vehicle load. Of the 129 checked vehicles categories O3, O4, 20 vehicles were assessed as unfit due to insufficient braking efficiency, of which, in 13 cases, apparently due to low vehicle load. A special regulation provides for a minimum load of vehicle submitted for technical inspection, but in practice this indicator is uncontrollable in real. For this reason, some technical inspection stations use an additional load of vehicle in the form adding goods, or by drawing the loading area to the roller brake tester with lashing straps. Practical measurements have shown that a sufficiently loaded vehicle with the correct load distribution leads to its correct measurement at the Technical Inspection.

The requirement for appropriate loading of the truck during the technical inspection process with consider a braking efficiency is a topical issue. According the similar studies [26], it is possible to expect compulsory equipping of Technical Inspection Stations with scales, or with compulsory reference brake force data from truck manufacturers.

References

[1] Methodical Instruction No. 74/2018 for the performance of brake system inspections of vehicles of categories M1 with a maximum allowed mass exceeding 3.5 tonnes, M2, M3, N2, N3, O3 and O4 in roller brake tester. Ministry of Transport and Construction of the Slovak Republic; 2018.

[2] ISO 21069-1. Road vehicles – Test of braking systems on vehicles with a maximum authorized total mass of over 3.5 t using a roller brake tester, Part 1: Pneumatic braking systems.

[3] Decree N. 137/2018 Z.z. laying down details on the operation of vehicles in road traffic. Ministry of Transport and Construction of the Slovak Republic; 2018.

[4] Government Regulation no. 140/2009, Regulation of the Government of the Slovak Republic laying down details on type-approval of motor vehicles and their trailers, systems, components and separate technical units intended for these vehicles.

[5] Rybianský M, Kuchynka R, Ondrejka P, Hron P. (2009). The using of the roller brake tester for evaluation of the braking efficicency in judge expertise TESTEK, s.r.o., Bratislava, available at: http://www.testek.sk/files/prez/brzdy_vsb_tatry_2009.pdf

[6] Šešera M, Ondrejka P. The brake system inspections of vehicles of categories M, N and O with maximum allowed mass exceeding 3,5 tonnes with using a new method of reference braking forces, TESTEK, s.r.o., Bratislava, available at: http://www.testek.sk/files/prez/sesera-ondrejka_zmena_brz dy_tazke_vozidla.pdf

[7] Ondrus J, Kolla E. (2017). Practical Use of the Braking Attributes Measurements Results. 18th International Scientific Conference Logi 2017. 134, 00044. https://doi.org/10.1051/matecconf/201713400044.

[8] Ondrus, J & Hockicko, P. (2015). Braking deceleration measurement using the video analysis of motions by SW tracker. Transport and telecommunication journal 16(2). (127 – 137). https://doi.org/10.1515/ttj-2015-0012.

[9] Vrabel, J., Jagelcak, J., Zamecnik, J. & Caban, J. (2017). Influence of Emergency Braking on Changes of the Axle Load of Vehicles Transporting Solid Bulk Substrates. Transbaltica 2017. Transportation science and technology 187. (89-99). https://doi.org/10.1016/j.proeng.2017.04.354.

[10] Idzikowski, A. (2017). Boolean model of HSUH leakage testing for the purpose of designing a diagnosing unit of selected damages of vehicle braking mechanisms. The Archives of Automotive Engineering – Archiwum Motoryzacji 78(4). https://doi.org/10.14669/AM.VOL78.ART6.

[11] Stopka O, Kampf R. Determining the most suitable layout of space for the loading units' handling in the maritime port. Transport. 2018;33(1):280–90.

[12] Idzikowski, A. (2017). Boolean model of HSUH leakage testing for the purpose of designing a diagnosing unit of selected damages of vehicle braking mechanisms. The Archives of Automotive Engineering – Archiwum Motoryzacji 78(4). https://doi.org/10.14669/AM.VOL78.ART6.

[13] Matuszak, Z., Nowak, A., Żabińska, I. & Martínez de Osés, F.X. (2019). Road safety on the example of the city of Bytom. The Archives of Automotive Engineering – Archiwum Motoryzacji 83(1). 43–57. https://doi.org/10.14669/AM.VOL83.ART3.

[14] Li, J., Zha, XJ & Wu, DS. (2011). The Theoretical Analysis of Test Result's Errors for the Roller Type Automobile Brake Tester. Computer and computing technologies in agriculture IV, PT 4. 347. (382-389). https://doi.org/10.1007/978-3-642-18369-0_44.

[15] Senabre C, Velasco E, Valero S. Comparative analysis of vehicle brake data in the Ministry of Transport test on the roller brake tester and on flat ground. Int J Automot Technol. 2012;13(5):735–42.

[16] Rievaj, V., Vrabel, J., Synak, F. & Bartuska, L. (2018). The effects of vehicle load on driving characteristics. Advances in science and technology-research journal 12(1). (142-149). https://doi.org/10.12913/22998624/80896.

[17] Kalašová A, Kapusta J. (2015). Motor vehicle safety technologies in relation to the accident rates. 15th International Conference on Transport Systems Telematics, (172–179).

[18] Figlus, T. (2013). Possibility to control and adjust the suspensions of vehicles. Activities of transport telematics. 395, 2013, 378–383. https://doi.org/10.1007/978-3-642-41647-7_46.

[19] Dai W, Jiang J, Ding G, Liu Z. Development and Application of Fire Video Image Detection Technology in China's Road Tunnels. Civil Engineering Journal. 2019;5(1):1.

[20] Moradzaeh, A. & Khaffafi, K. (2018). Comparison and Evaluation of the Performance of Various Types of Neural Networks for Planning Issues Related to Optimal Management of Charging and Discharging Electric Cars in Intelligent Power Grids. https://doi.org/10.28991/ijse-01123.

[21] Kordani AA, et al. Effect of adverse weather conditions on vehicle braking distance of highways. Civil Engineering Journal. 2018;4(1):46.

[22] Ližbetin J. Methodology for determining the location of intermodal transport terminals for the development of sustainable transport systems: A case study from Slovakia. Sustainability. 2019;11(5):1230.

[23] Barta D, Mruzek M. (2012). Using of braking in real driving urban cycle. LOGI - Scientific Journal on Transport and Logistics, 3(1), (14-22). ISSN 1804-3216.

[24] Cujan Z, Fedorko G. Supplying of Assembly Lines Using Train of Trucks. Open Eng. 2016;6(1):426–31.

[25] Varecha D., Kohar R. & Brumercik F. (2019). AGV Brake System Simulation, LOGI – Scientific Journal on Transport and Logistics, 10(1), 1-9. https://doi.org/10.2478/logi-2019-0001.

[26] Rybianský M, Ondrejka P, Testek s. Slovakia. Roller Brake Testers and Vertical Load Measuring in ISO 21069-1. available at: http://www.testek.sk/files/WG1_Subwg/WG1_Subwg_Brakes_02_2018_003_ISO_and_load_measuring.pdf