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Study of the Influence of Brake Testers Characteristics in the Measurements When Testing the Electronic Park Brake at Ministry of Transport Facilities

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Abstract

This research is focused on the test of the Electronic Parking Brake (EPB) at several Ministry of Transport (MOT) facilities to see if there are differences between data obtained. The parking brake force have been measured on three different brands of roller bed testers from MOT facilities such as: Maha, Ryme and Vteq. Knowing that the rejection threshold is the same for all testers, the Efficiency of parking systems is also obtained to compare results between al testers used. Finally, it can be said that the parking brake measurement vary depending on the MOT brake tester characteristics used for the test. Additionally, a probability of passing the test of the EPB at each tester is calculated.

1. Introduction

The study objective of this research is to see if different Ministry of Transport (MOT) testers will provide different results when testing the parking brake system with same vehicle. But also, it is has been studied if the same vehicle will pass or not the test knowing that all testers have the same rejection threshold.

An Electric parking brake (EPB) is actuated when pressing a switch, see Figure 1, then motors actuate on each brake calliper squeeze the pads into the disc of each wheel, see Figure 2. You'll hear a reassuring whirring of the motors as the button is pressed (or pulled), meaning that you know that the car is held safely, which isn't always a guarantee with a regular handbrake. This technology consists on an electric motor to apply the brake pads to either the front or the rear wheels. It is used to help hold vehicles stationary when the car halts either on the flat or on a gradient.

In other words, an Electric Park Brake system uses electrical cables and a control switch instead of a typical foot pedal or hand lever. With less cabling to route, it's a lot easier for automakers to design their interiors and to add new features and options. It also reduces weight, contributing to fuel efficiency gains. This technology will be in the future the standard feature on new cars. This technology will replace the traditional manual hand brake lever parking brake with an electronic control. Electric Park brake is integrated with a vehicle's electronic stability control system for a better stopping power in an emergency braking situation. In normal driving, this technology is pretty convenient because it gives to the four wheels anti-lock functionality when it is necessary.

Moreover, this technology can hold the vehicle in a stopped position on a slope. The commodity is to not to keep the brake pedal depressed or to work the hand brake. But also, it can make heavy traffic and traffic jams less tiring.

The aim of this research is to analyse if force data obtained with different Ministry of Transport (MOT) brake testers with characteristic are different when measuring the parking brake when using Electric parking brake (EPB) system from three brands of testers such as: Maha, Ryme and Vteq MOT brake testers.

The goal of this research is to study the influence of the MOT brake tester characteristics in the parking-brake measurements.

In this case, the vehicle was a Volkswagen Passat, and it was equipped with an Electronic Parking Brake (EPB) system.

The test consists on pressing the ESP switch like in Figure 1 and motors on each brake calliper will squeeze the pads into the disc to hold safely the car. Thus the parking brake will be checked in order see any malfunction. [7-10, 15-16].

Figure 1. *Electronic Stabilization Program (ESP).*

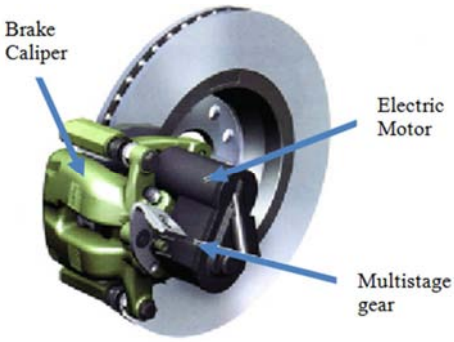

Figure 2. *Brake calliper actuated by motors.*

2. Materials and Methods

For the parking brake test it is needed to place the vehicle on rollers of the brake tester at the MOT station when the emergency brake is not actuated and then rollers will rotate with constant speed of around 3-5km/h and without acceleration [1-6]. Then, the parking brake will be actuated until the vehicle slypes 100% [5]. This procedure is indicated in the in the "MOT procedure manual" [1-2] from Ministry of Industry, Tourism and trade of Spain (2016) [3-4]. Three different brands of Mot testers have been used for this research. It has been used four testers in total. These testers had different characteristics, but the same rugoses of the rollers surface of 45µm. See Table 1 and Figures: 3-6.

Table 1. *Mots brake tester characteristics used in each city.*

A. 2 MOT testers at Ondara city:		
1-VTEQ VITEU 3000		
Roller diameter	Distance between rollers	Velocity of the test
202 mm	400 mm	5,4 km/h
2- VTEQ 7000		
Roller diameter (mm)	Distance between rollers(mm)	Velocity of the test
270	475	3km/h
B. 1 MOT testers at Orihuela City:		
MAHA IW2 RS2		
Roller diameter	Distance between rollers	Velocity of the test
204 mm	400mm	5km/h
C. 2 MOT testers at Pilar the la Horadada city:		
RYME FRU4		
Roller diameter	Distance between rollers	Velocity of the test
270 mm	485 mm	5km/h

a

b

c

Figure 3. *a) RYME FRU4 MOT roller tester, b) KN-brake of each wheel, c) Efficacy of both rear wheels.*

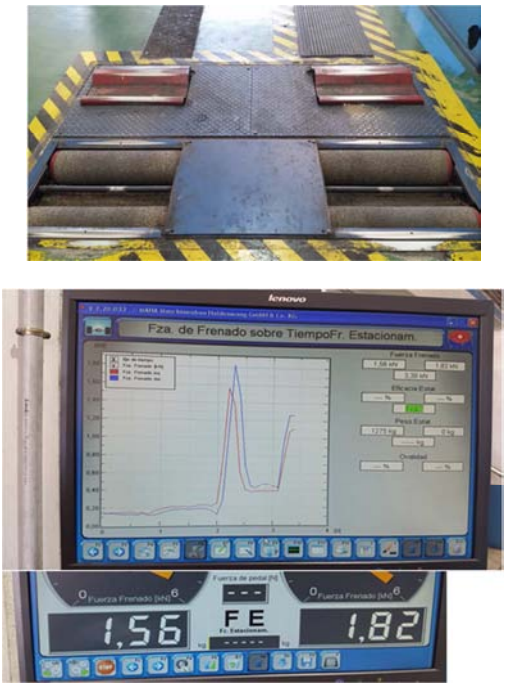

Figure 4. *MAHA IW2 RS2 MOT tester and results.*

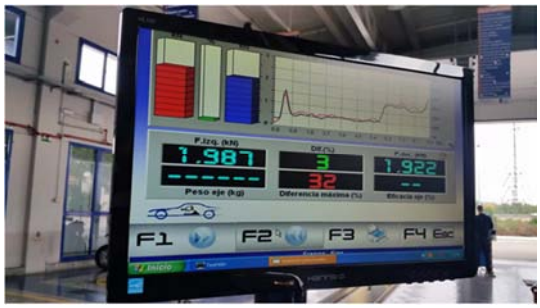

Figure 5. *VTEQ VITEU 3000 MOT tester and results.*

Figure 6. *VTEQ 7000 MOT brake tester and results.*

In previous researches the authors have demonstrated that some parameters of the vehicle such as: tyre pressure, effective radius, wheel angles and weight on wheel vary the brake measurements [11-14]. Therefore, these vehicle characteristic were controlled to be the same during all experiments. Then, measurements variations of parking brake tests will be due to the roller bed characteristics. The differences between MOT testers are: separation of the rollers and roller diameter.

Previous studies carried out by the authors stablished that brake force data obtained with different MOT testers are different. But this is the first time that a comparative analysis of parking brake data measured on MOT brake tester is done with the same vehicle with the same tyre, Continental Contact 215/55R Radial Tubeless, with the same tyre pressure.

3. Experimentation

The vehicle used for the experiments was a Volkswagen Passat. It was equipped with advanced Electronic Stabilization Program (ESP) but also equipped also with anti-lock braking system (ABS) that stops wheels locking. The ESP detects critical situations in order to act to stop skidding before it begins.

In previous researches, it was demonstrated that the braking force required to stop the wheel increased as the tyre pressure increase when the car used a Continental Contact tyre, due to the elasticity of the tyre. When tyre pressure was increased when using a tyre with high levels of elasticity the rigidity of the tyre increased and the brake force transmitted to the sensor of the MOT brake tester was higher. Therefore, all experiments were carried out with the same tyre: Continental Contact, also with the same tyre pressure in the 4 tyres. [12-13].

It was measured the “Parking brake force” (PBF) from each rear wheel. Moreover, the total efficiency was calculated [6] to know if the vehicle passed the test of PBF. To pass the test the minimum efficiency for all MOT brake testers is 16% and all MOT parking brake testers have the same rejection threshold. It is indicated in the MOT directive the directive 96/96 CEE [6].

3.1. The Minimum Efficiency or Rejection Threshold

To calculate the minimum force to obtain 16% of Efficiency and pass the MOT parking brake test for vehicles [6] as stated in and the manual of MOT inspection of vehicles it is used the following equation 1:

$$E = \frac{F_{total}}{m * g} 100 \quad (1)$$

When:

E= % of efficiency, Minimum=16%

F_{total}= Sum of parking braking forces of both wheels of the axe.

m= Maximum permissible vehicle mass in kg, it is: 1452kg of vehicle weight + 75 kg of driver=1527kg. 60% for front axle 916,2 kg and 40% for rear axle [7-10]= 610,8kg

g = Gravity.

The minimum brake force on each front wheel to pass the test should be:

On rear wheels:

F_{total}=E%*m*g/100=16*(610,8 rear axle)/100= 0,97 daN (2)

3.2. Data Obtained with Four MOT Testers

Four brake testers have been used for the experiments with different roller diameter and different distance between rollers to analyse the influence of MOT characteristic in the parking brake data obtained.

It can be seen in Figure 7: DaN of force measured of each tyre on the four MOT testers that the vehicle will pass all the test but better results are obtained with the Vteq3000 tester.

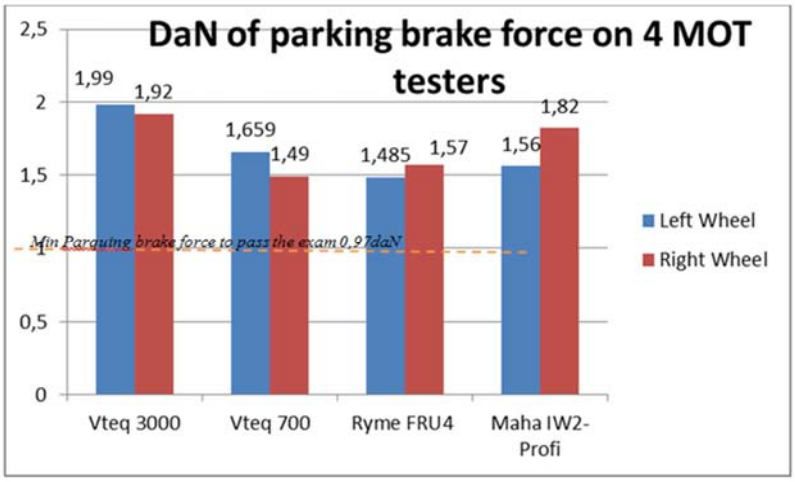

Figure 7. *DaN of force measured for each tyre on the four MOT testers.*

The difference between the highest value (1,987 daN) and the lowest value (1,485 daN) were 0.502 daN for the left wheel and 0.428 for right wheel. Differences of Brake measurements at MOT-brake testers are 25,51%.

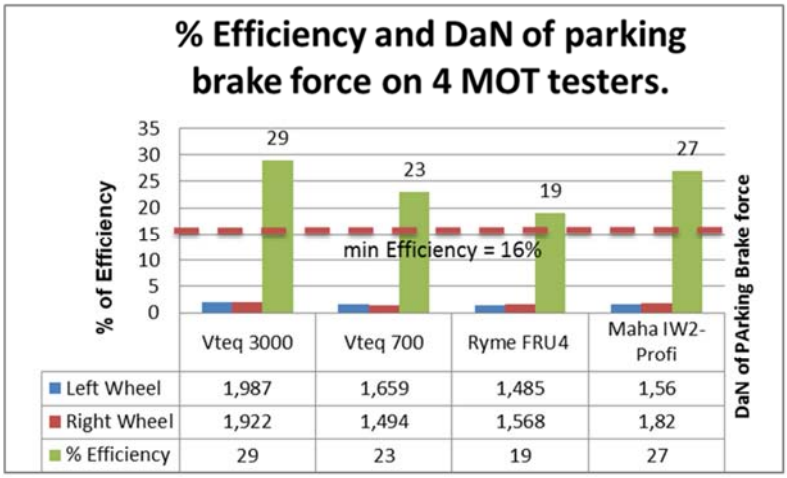

Figure 8. *% of Efficiency and DaN of parking bake data on the testers.*

Moreover, in Figure 8, it can be seen that higher data values of Efficiency Parking Brake were measured by Vteq 3000 tester and lowest values were obtained with the Ryme Fru4 brake tester.

The highest difference of Brake Efficiency measurements at the four MOT-brake testers is 34.5%.

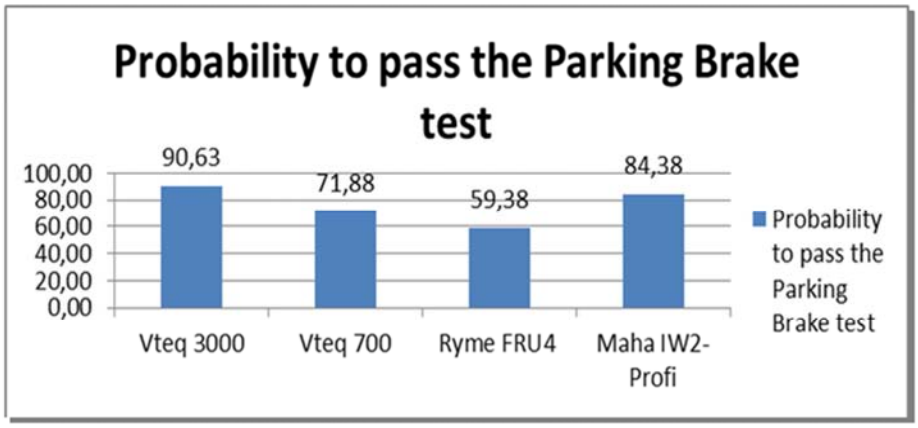

Figure 9. *% of Probability of passing the parking tests at MOT facilities.*

The maximum difference of probability of passing the test is 31,25%, when comparing testers such as: Vteq 3000 and Ryme Fru4.

4. Discussion

MOT testers are ordered from the higher Parking brake data obtained to the lower parking brake data obtained in table 2. It can be seen that roller diameter increases as the Parking Brake data decreases.

Table 2. *Brake testers ordered from higher to lower parking brake values.*

Brand and type of MOT brake tester	Roller diameter	Distance between rollers
VTEQ VITEU 3000	202	400
MAHA IW2 RS2	204	400
VTEQ 7000	270	475
RYME FRU4	270	485

This phenomenon is because slippage between rollers and the wheel is:

$$\text{Slippage} = \left(1 - \frac{w * r_{Wheel}}{w * r_{Wroller}}\right) * 100\% \quad (3)$$

Considering that the Parking Brake torque and the tractor force of rollers are always the same. As it can be seen in equation 3 and in table 2 that higher roller diameter produces higher slippage; therefore the brake measured by the MOT brake tester sensor will be lower, for the same tractor torque from rollers and the same Parking Brake provided by the calliper when the EPB button is pressed.

On the other hand higher distance between rollers will produce higher values of θ and lower values of cosθ and then higher values of brake torque Mf needed to stop the wheel.

$$Mf = 2Mt - 2\,\mu\,P\cos\theta\,r_e \quad (4)$$

Considering:

r_e= Effective radius of the wheel on rollers

r_2=r_3 radius of rollers

M = Sum of moments

Mf = Braking torque applied to the vehicle wheel

Mt = Roller tractor torque, Mt2 = Mt3= constant.

Fr = Frictional force, Fr_2=Fr_3

μ = Rollers roughness

P = Weight on the wheel

Cos θ = Angle between the symmetry axis and the line between wheel-roller centres.

If the Brake parking torque is the same, when the distance between roller increases higher values of slippage will be obtained and the Parking brake torque measured by the sensor of the brake tester will be lower.

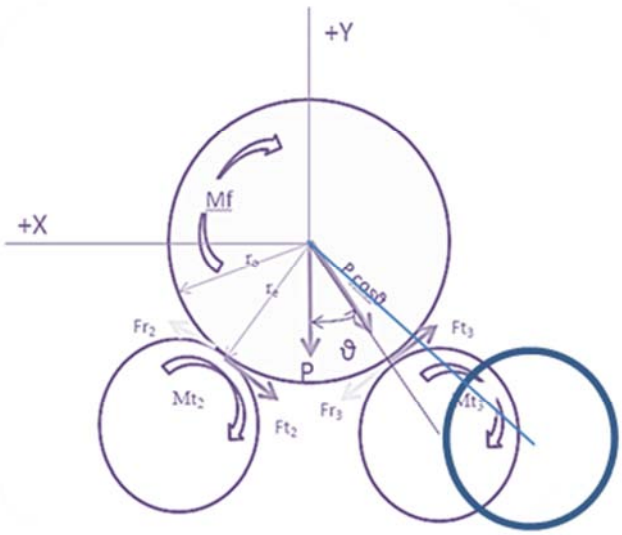

Figure 10. *The variation of the angle when the distance between rollers increases.*

5. Conclusions

After analysing Parking Brake obtained with four different MOT brake testers it could be said, that the Volkswagen Passat will have 25,51% less probability to pass the parking brake test on a Ryme-Fru MOT brake than on a Vteq 3000 MOT brake tester.

The aim when the EPB of the vehicle is tested at MOT stations is to know if vehicle parking brakes are in good condition or not, but it is not expected a parking brake measurement vary depending on the MOT brake tester characteristics.

It can be seen in graphics provided that different parking brake results can be obtained due to the characteristic of the MOT tester used. In this research 25,51% of difference of Parking brake data have been measured comparing the four brake testers studied.

Furthermore, it is concluded that the different diameter of rollers of MOT brake testers produces a high variability of Parking Brake data of MOT testers. On the other hand, when there is higher distance between rollers brake values measured are higher for the same roller diameter.

MOT stations have several types MOT brake testers with roller diameter and it can be said that the vehicle could pass or not the parking brake test due to the brake tester used.

The recommendations of the researchers are: to use the same MOT brake tester at all MOT stations, and to use other type of brake tester verification system without any dragging of wheels and without slippage between rollers and wheel.

Acknowledges

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