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Analysis of Parameters Influence: Tire Pressure, Weight, Tire Tread, Tire Type and Distance Between Rollers, When Vehicles Brakes On Ministry Of Transport Roller Bed And On Flat Ground

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Abstract— This study gives a comparison between what occurs when braking on Ministry of Transport (MOT) brake tester and the flat ground. The results from this research and the exhaustive comparative study carried out by the mechanical engineering staffs at the mechanical laboratory at the Miguel Hernández University in Elche [2] have led to the following main conclusions: By varying the tire pressure, weight, tire tread, tire type, and distance between rollers results can vary on the MOT brake tester. This paper demonstrates that the MOT brake testing results can vary depending on some parameters. Braking data on Ministry of Transport have been also compared with braking on flat ground with the same parameters conditions. Differences have been quantified.

Index Terms— **Braking, Ministry of Transport (MOT) brake roller tester, roller bed, tire pressure.**

I. INTRODUCTION

This is work deals the study of the influence of tire pressure, tire tread, and overweight of the vehicle in the longitudinal braking action and sliding on three MOT brake testers and its comparison with the brake-sliding on a flat road.

When a vehicle is taken to the MOT testing facilities, this includes a brake test made on a roller bed to check the brake circuit. Several questions need to be answered over the efficiency of MOT testing facilities.

This research analyse if braking on a roller tester faithfully reproduce braking on flat ground, how far does tire parameters studied affect the measurements taken on the roller bed. Ultimately, we study if the MOT brake tester assesses rightly the condition of brakes 100% efficiently.

The aim of the study is to find out a vehicle's braking capacity by measuring slippage on a brake tester at MOT centres, compare the measurements with other, similar ones taken on flat ground, and use the result to assess the reliability of the machine in testing brake systems.

II. TESTING METHODS

The vehicle used in the research was a used Renault 21, Model: Nevada, 7-seater, diesel, with a mileage of 90,000 kilometres. It has front discs brakes with sliding clamps, use DOT 4 brake fluid and a tandem brake pump. The rear wheels have drum brakes.

Firstly it is described the test onto MOT roller bed tester and secondly the brake on flat ground in order to compare the data results with the same parameters conditions.

A. Test 1

The test on the brake roller tester at the MOT centre is carried out by placing the vehicle on rollers. The emergency brake should not be actuated. The car stops on the roller bed. Then the rollers rotate at 5km/h of speed. This

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velocity is indicated in the "MOT procedure manual" from Ministry of Industry, Tourism and trade of Spain (2006) [1-3] . Brake pedal will be pressed until 100% of slippage is obtained.
The torque on the rotation axis of the rollers is measured using a strain gauge. The pressure in the brake hydraulic circuit on the right wheel of the vehicle is also measured using a hydraulic sensor in hydraulic pipe of the right wheel. The angular velocity of the rollers and vehicle wheels are measured using two OMRON encoders. The first one fitted to the brake roller tester and the second one in contact with the front, right-hand wheel of the vehicle.

Data were recorded using an LMS Pimento portable, multi-channel analyser.

To ensure that the rotation of the encoders was synchronised with the rollers and the wheel, connectors were built as shown in figures 3 and 4, where a spring can be observed ensuring good contact.

Fig 1. Test 1 measuring on the brake roller tester at the MOT centre.

The pulses captured from the rotation of the encoders in both tests were converted into a signal proportional to the angular velocity, using a frequency converter data acquisition system.

Fig 2. Encoder fitted to brake roller tester

Fig 3. Encoder fitted to the vehicle wheel

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B. Test 2

In this test, the vehicle runs on flat ground until 40-50 km/h of velocity is attained. We need that velocity to obtain 100% of slippage [5,7,9,10,11]. Then it stops until the car slides 100%. A fifth wheel, driven by the vehicle, has been attached to measure slippage, see figure 5, and which is used as a reference.
It has been used the same sensors in both tests.

The track is supposed to be completely flat, with no changes to adherence coefficients in the route. A spring was fitted to the drive wheel to guarantee a good contact.

Fig 4. Fifth wheel, or drive wheel.

Firstly, the only difference in the measurements is the change in tire pressure in both tests.

Once the test data was recorded, any that were non-representative were filtered and deleted, for both test 1 and 2, in order to obtain better results and provide a suitable interpretation.

The slippage using the expression [5]:

$$\text{Slippage} = 1 - \frac{\text{speed of vehicle wheel}}{\text{speed of fifth wheel}} \qquad (1)$$

III. RESULTS

A tire whose pressure is too low overheats and the surface does not wear uniformly, consumes more fuel, is less durable [1] [3] becomes more sensitive to impact and less resistant to fatigue, and may suffer irreparable damage. At a pressure of less than 1 bar, the tire may even come loose from the rim, a situation that has been avoided in this study by using pressures of 1 bar or higher. Tires have been inflated to 1, 1.5 and 2 bar. These three values clearly show how events develop, although the range was increased in later studies.

The measurements obtained from both tests were the brake pressure on the vehicle and the slippage on the braking wheel.

A comparative analysis was made of the braking and slippage measurements for the same test carried out with different tire pressures, to see how the test evolved.

The braking and slippage data were also compared for both tests at the same tire pressure, to see the difference in braking measurements between the roller tester and flat ground.

A. Comparison of braking-slippage data at various bar of tire pressure in both tests:

1. Results and discussion from test 1

The bar in the circuit, when the brake pedal is pressed and the corresponding slippage obtained in test 1 for different tire pressures are given below.

Measurements obtained from the pressure sensors in time are as shown:

From the data obtained, only the measurement up to maximum slippage is taken into account, which corresponds to 100% slippage.

Once the measurements have been treated, which means removing anomalies like sensor disconnection or wire disconnection and obtaining the mean for the experiments, the following summary for test 1 was obtained for each value of tire pressure:

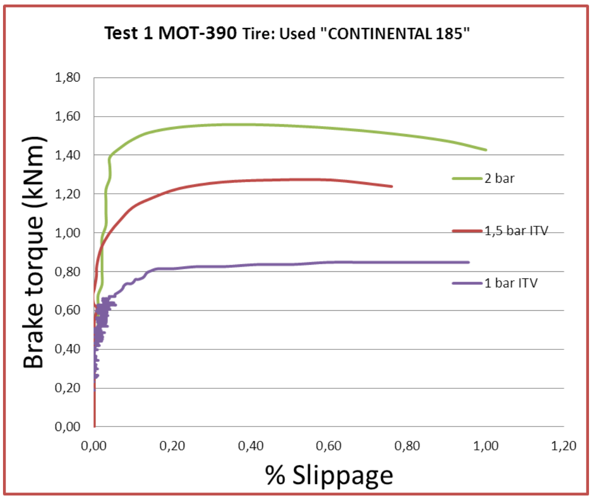

Fig 5. Pressure in brake circuit for slippage in test 1 at various tire pressures.

As can be seen in the graph in fig. 5, as the tire pressure increases, so does the braking pressure needed in the braking system to be able to stop the vehicle on the MOT roller tester, and there is some delay in the increase of slippage. This means that, when tire pressure is too low, the maximum slippage value can be obtained with less pressure in the vehicle's brake circuit.

2. Results and discussion from test 2

This test shows that the brake curves in relation to slippage at various tire pressures present smaller differences than in the MOT test 1, as shown in fig. 6.

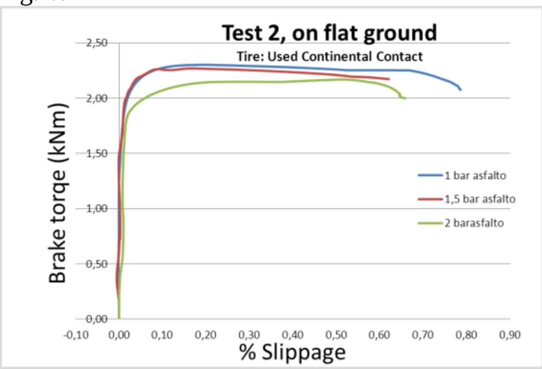

Fig 6. Pressure in brake circuit for slippage in test 2 at various tire pressures.

It is observed that the maximum pressure applied in the brake circuit to stop a vehicle moving on flat ground decreases a 6,09% as the tire pressure increases from 1 to 2 bar, see figure 6 , but this is not as significant as the increment of 48.1% of maximum value of pressure in the brake circuit, in test 1 to obtain 100% of slippage, as the tire pressure increases from 1 to 2 bar, see figure 5 [7].

B. Comparison of results from both tests

According to the tests carried out, the pressure in the brake circuit required to stop the wheel in the test on flat ground decreases as the tire pressure increases [7]. Therefore, at pressures lower than 2 bar, a higher bar is required

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in the brake circuit to stop the vehicle, a situation that should be avoided, in order to consume less energy and stop the vehicle in a shorter time [6].

However, this result does not correspond to what occurs on the brake roller tester. As can be seen in fig. 5, the maximum pressure applied to the brake circuit to obtain maximum slippage (and the vehicle leaves the tester, as a result), increased as the tire pressure increases, so that greater hydraulic pressure in the brake circuit has to be applied with a high tire pressure, for the vehicle to leave the tester [7].

One of the reasons why this tendency arises at peak braking values in the MOT results may be that the tire deforms on the rollers, so that, at higher tire pressures, the tire deforms less, and the contact area between the tire and roller is less, which means that a smaller friction area with the rollers, requiring greater force before the vehicle can leave the tester.

On the other hand, the braking force required to stop the vehicle on flat ground, whatever the tire pressure, is always greater than that required on the roller tester, due to the fact that, when a moving vehicle is stopped, forward motion inertia must be counteracted [5], which does not happen on a brake roller tester.

Quantitatively, it can be said that, if the tire pressure is 2 bar, the pressure sensor in the brake roller tester test captures a 28% difference in measurements from the test on flat ground, And this increases to 65% if the tire pressure drops to 1 bar. It can be concluded that a brake roller tester does not reproduce the braking on flat ground.

In the other hand, the minimum brake efficiency to pass the MOT test is 48-50% for vehicles without ABS, and our vehicle has not ABS, as it is said in the directive 96/96 CEE [2], and the manual of MOT inspection of vehicles [3]. The efficiency is:

$$E = \frac{F_{total}}{m * g} 100 \qquad [2\text{-}4]$$

E= % of efficiency
F= Sum of braking forces of all wheels.
m= Maximum permissible vehicle mass in kg=1245 kg
g = acceleration of gravity.

The vehicle breaks 60% with front wheels and 40% with rear wheels Then, the minimum force to pass the MOT test is:

$$\mathrm{Fdd} = \frac{\mathrm{E} * \mathrm{m} * \mathrm{g}}{100} * \frac{60\%}{2}$$

$$\mathrm{Fdd} = \frac{50\% * 1245\mathrm{Kg} * 9.8\ \mathrm{m}/s^2}{100} * \frac{60\%}{2}$$

$$= 1830.15N =$$

1.8 kN**: "**Rejection threshold**"**
We can conclude that the car will pass the test 1 only with the pressure of wheels, 2,5 bar or more and it will not pass the MOT test with a pressure of wheel lower than 2,5 bar, when the brake system is right.

C. Comparison of results using different MOT brake testers.

The "Rejection threshold" is the same for every MOT station but it is allowed that every station can use a different brake tester. It has been analyzed how the distance of wheel base of the roller bed can affect to brake data measured in the test. Forces and torques on MOT brake tester has been identified in fig 7.As it can be observerd in table 1, the distance of wheel base of the roller bed can affect to brake data measured in the test due to the different angle between rollers and wheel [6].

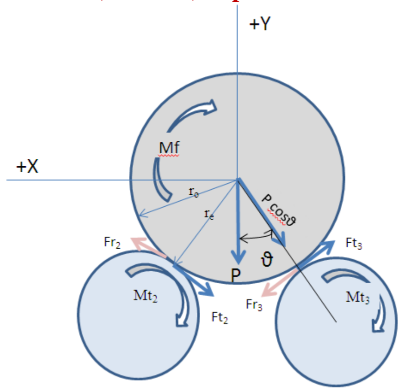

Fig 7. Forces and torques on MOT brake tester

Table 1. Angle betwen rollers and wheel for three MOT testers.

	MOT-390	MOT-410	MOT-450
θ angle	42,2º	45º	50,9º
Cos θ	0,74	0,707	0,63
1/ Cos θ	1,35	1,41	1,5848

Difference 4,2% Difference 11,6%

As it can be seen in fig 8. Brake data obtained from three different MOT tester are diferent. The only differnece between MOT 410 and MOT 450 is the wheel base, thereby 11,6% of difference of data are obtained when tire pressure is 1 bar.

The difference between MOT 390 and MOT 410 is due to the rugosity of rollers and the wheel base. If it is consided that a 4,2% is due to the wheel base as it can be seen in table 1, a 27,7 % is due to the difference of rugossity between rollerers 49µm for MOT410 -450 and 33µm for MOT390.

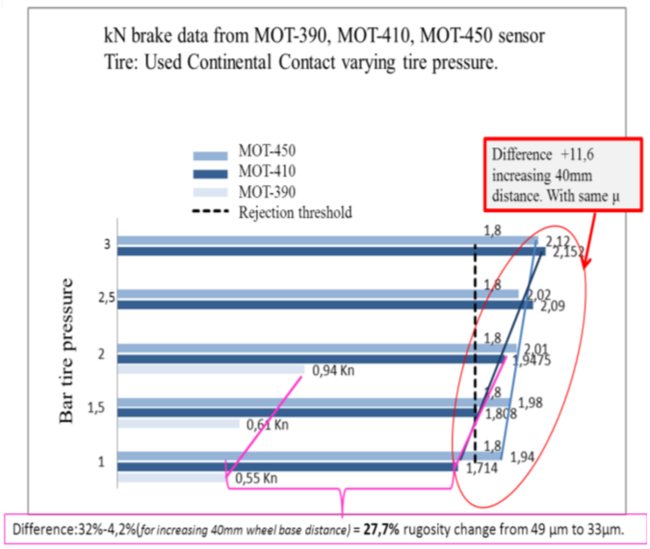

Fig 8. KN brake data on MOT 390, MOT 410, and MOT 450

If it is used the MOT450 brake tester with the same tire type but with different worn out of tire, 3 mm of difference, only 1.5% of diference brake data can be measured, so it can be concluded that the worn out is not an parameter to control in the measurements.

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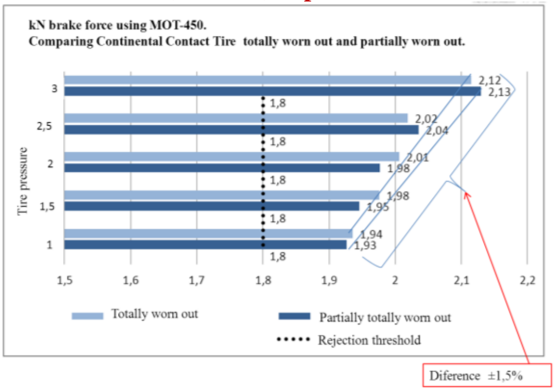

Fig 9. KN brake force on MOT 450 using different tire type

Two different tire types has been used in the measuremnts to compare data results:

CONTINENTAL CONTACT 185/65/R14 Tubules	FIRESTONE 185/65/R14

Fig 10. two tire types used for the research

At MOT410 station, as it can be seen in figure 11, the tire type used in the brake test influenciates strongly in data obtained. The same vheicle could pass the test using a Continental Contact tyre and will not pass the test using a Firestone when tire is inflated 3 bar of pressure. In the other hand will pass the test with a firestone and will not pass the test with a Continental Contact tire when tire is inflated 1 bar of pressure.

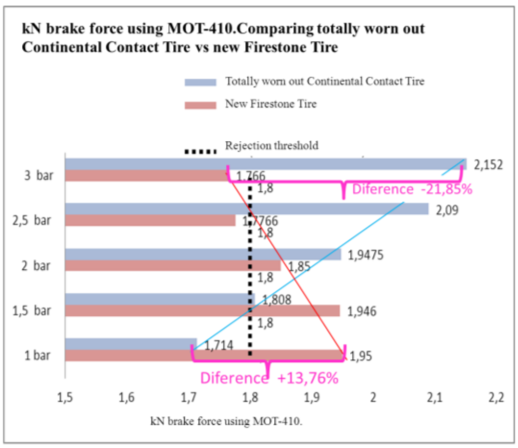

Fig 11. kN brake force using MOT 410 Comparing two types of tires.

At MOT 450 it can be observed that tire type is also a parameter that can vary the brake results. A vehicle with a continental Contact tire will have 15% more possibilities to pass the test than one with a Firestone.

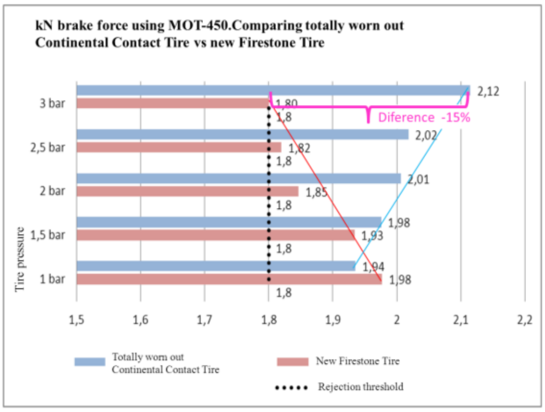

Fig 12. kN brake force using MOT 450. Comparing a two tire types.

Finally, if weigh is increased brake data at MOT450 station can increase until a 12% when tires are inflated 2,5 bar.

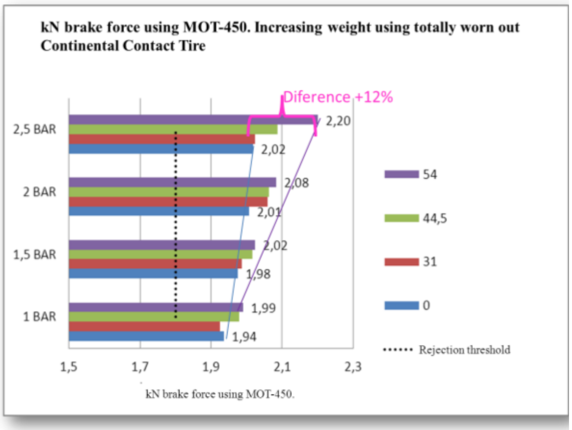

Fig 13. KN brake force using MOT450. Comparing different weight on wheel.

To summarise, it can be seen in table 2 differences in brake data measured by MOT brake testers when different parameters vary:

Parameters	**From 1 to 3 bar tire pressure**
Tire pressure	At MOT-450 maximum difference 8,5%
	MOT-390 max. difference 41,4%
Rollers roughness	It decreases 27,7 % when it changes from 49 µm to 33 µm
Tire type (Continental Contact vs Firestone)	It increases +5,3 (1 bar) to +21,8% (3bar)
MOT wheel base	+ 11,6% (1bar) to -1,5% (3bar) Comparing MOT-410 vs MOT-450

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Weight increment	+2,5 a +12% increasing 54kg on each wheel.
Tire worn out Continental Contact Tire	+0,5% (1 bar) +1,5% (3bar), Comparing 3mm vs 6mm tire tread.

IV. DISCUSSION AND CONCLUSIONS

The study was carried out fully ensuring that the control of measurements was the same for both tests, 1 and 2, and we proved that there are large differences in pressures in the vehicle brake circuit required to stop it before obtaining 100% slippage.

It is observed that the maximum pressure applied in the brake circuit to stop a vehicle moving on flat ground decreases a 6,09% as the tire pressure increases from 1 to 2 bar, see figure 6, but this is not as significant as the increment of 48.1%, in test 1 to obtain 100% of slippage, as the tire pressure increases from 1 to 2 bar, see figure 5 [6]. So there is an antagonist tendency tracking the pressure measurements in the brake circuit related to slippage for the 1 to 2 tire pressures of both test.

On flat ground, it was demonstrated that, as tire pressure increased, less braking force was needed to stop the vehicle [7] [8] [9] [10], and the opposite was true for the roller test when tire pressure has increased, the braking force required also increased, i.e. the pressure in the brake circuit has to be increased to obtain 100% slippage. This means that, as tire pressure increases, the brake roller tester captures measurements that are closer to those of the flat ground test.

Low tire pressure on the MOT brake roller tester returns values on the brake pressure circuit that may vary up to 65% from the real braking force required on flat ground.

Thus, it has been demonstrated that the efficiency of brake depends on the condition of the brakes, but also on the tire pressure at the time of testing on a brake roller tester. As we have studied the car would pass the test 1 only with the pressure of wheels, 2,5 bar or more and it will not pass the MOT test with a pressure of wheel lower than 2,5 bar, when the brake system is right.

So Tire pressure variation can produce a variation in brake measured at MOT-450 maximum difference of 8,5% and MOT-390 max. difference 41,4%.

Variation of other parameters can produce different brake data measured in any MOT station:
Rollers roughness variation from 49 µm to 33 µm can decreases brake data a 27,7 %.

If it is used different tire type like Continental Contact or Firestone brake data results increases +5,3 (1 bar) to +21,8% (3bar) at the same MOT 450 station.

When MOT wheel base vary from MOT-410 to MOT-450 brake results vary + 11,6% (when tire is inflated 1bar) to -1,5% (when tire is inflated 3bar).

When Tire is whether or not worn out using a Continental Contact Tire brake data can increase +0,5% (when tire is inflated 1 bar) +1,5% (when tire is inflated 3bar).

And for a Weight increment of 54 kg on each wheel brake data can increase from +2,5 (when tire is inflated 1 bar) to +12% (when tire is inflated 3bar).

Finally we can doubt on the suitability of a brake roller tester to determine whether or not the brake system of a vehicle is in good condition.

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REFERENCES

[1] CITA (1999). Standardization of criteria for evaluation of defects diagnosed during the inspection of vehicles.

[2] European Community (2002). Directive 2002/78/EC Official Journal of the European Communities, L 267/23, October 4, 2002.

[3] Ministry of Industry, Tourism and Trade of Spain (2006). Inspection Procedures Manual station ITV.

[4] Ministry of Industry, Tourism and Trade of Spain (2009). National Regulation Vehicle Inspection in Law No. 29237

[5] Pablo Luque, Daniel Álbarez, Carlos Vera. Automobile Engineering, Systems and Dynamic Performance. Publisher: Thomson.

[6] C. Senabre , E. Velasco, M. Sanchez. Study of mathematical models to simulate tire movement and interaction with the surface León Mechanical Conference, December 2004.

[7] F. Aparicio y C. Vera, Teoría de los vehículos automóviles (2), (2001) p. 69. (Theory of automobiles)

[8] J. C. Dixon, "Tires, Suspension and Handling", Society of Automotive Engineers, Inc. The Open University, Great Britain , 1996

[9] Measurement of inertial properties and suspension parameters of heavy highway vehicles, sae paper nº 730182, Society of automotive engineers, Warrendale, Pa. 1978.

[10] D. García-Pozuelo, A. Gauchía, B.L. Boada, Improvements in the inspection procedure of brake disc warping

[11] V. Díaz. Securitas Vialis (2009) 3:25–32

[12] Mavros, G; Rahnejat, H; King, P Investigation of steady-state tire force and moment generation under combined longitudinal and lateral slip conditions. Source DYNAMICS OF VEHICLES ON ROADS AND ON TRACKS351-360 2003. Conference Title 18th Symposium of the International-Association-for-Vehicle-System-Dynamics, Kanagawa Inst Technol, Atsugi,JAPAN

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Carolina Senabre, received in 1998 the Engineer degree from the Polytechnic University of Valencia. PhD degree on Industrial Engineering, at the Polytechnic University of Elche. From 1998 to 2000, she became a Professor at high school "La salle" in Alcoy. From 2000 to 2001 she was a member of the research staff at the Engineering and buildings s.l,, where she worked in the fields of structural design of buildings. From 2001 to now, she is a Professor at the Miguel Hernández University of Elche. She is teaching drawing, and Mechanical Design, and managing some research projects in those fields. She has authored numerous publications and contribution to congresses, and he is taking part in the publication of two books on teaching drawing, and Mechanical Design.

Emilio Velasco Sanchez received in 1992 the Industrial Engineer degree from the Polytechnic University of Madrid (Spain).And received the PhD degree on Industrial Engineering at 1997. From 1993 to 1998, he was a Professor in the Mechanical engineering division at "Carlos III University" in Madrid. And he was also a member of the research staff at the Automobile Research Institute (INSIA), where he worked in the fields of passive safety of vehicles, structural design and accidentology, and he was involved in numerous national and international projects. In 1998, he became a Professor at the Miguel Hernández University of Elche, where recently he has been appointed Director of Engineering studies. He is teaching mechanical technology, and transport security in Industrial Engineering. He has authored numerous publications and contribution to congresses.

Sergio Valero received in 1998 the Industrial Engineer degree from the Polytechnic University of Valencia (Spain). PhD degree on Industrial Engineering. From 2000 to 2002, he was a Professor of the Polytechnic University of Valencia in the engineering automatic system division and he was involved in numerous national projects. In 2002, he became a Professor at the Miguel Hernández University of Elche, where he has been appointed Director of the Electrical Engineering Division. He is teaching Electric technology, Electric Machines, Theory of electric installations and managing some research projects in those fields. He has authored numerous publications and contribution to congresses, at the moment he has taken part in the publication of two books on Electric Machines and electric technology.