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UNIVERSITY INSTITUTE OF AUTOMOTIVE RESEARCH

REPORT ABOUT TRIALS MADE ON VIGIA EQUIPMENT

Ref: **10IA1747**

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INDEX

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1.- INTRODUCTION

This report refers to the sample that will be described below and talks about a laboratory trial made on it with the purpose to demonstrate its functioning and conditions over a tire.

Applicant of the trial:	Fernando Zanón on behalf of EUROCOLVEN, S.A. Ctra de Andalucía Km 33,800 45224 Seseña (Toledo)
Trial date:	INSIA Ctra. de Valencia Km 7 Campus Sur UPM 28031 Madrid
Report reference:	10IA1747

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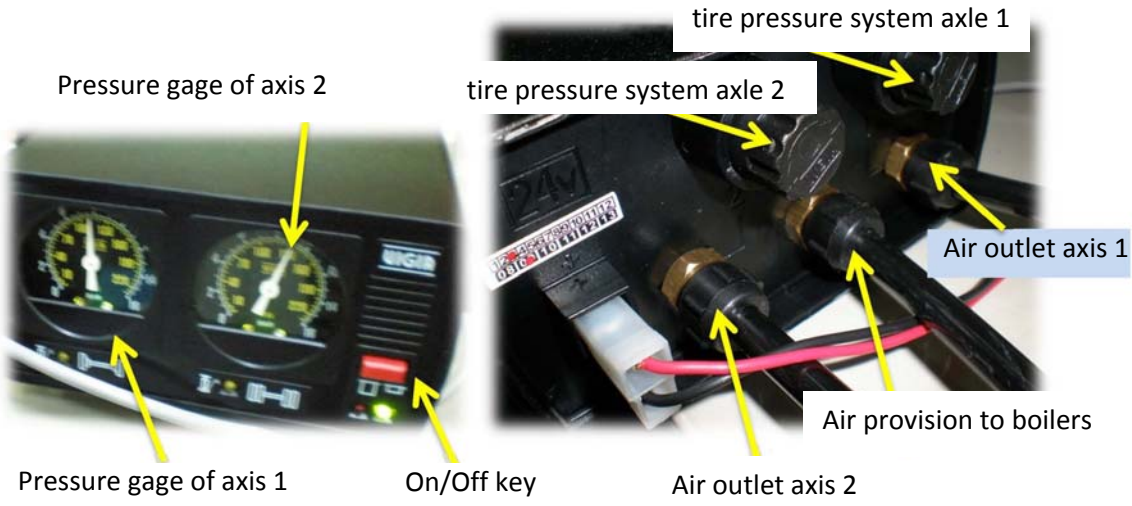
2.- SAMPLE DESCRIPTION

The VIGIA equipment is a tire pressure system that keeps the pressure of tires in vehicles at a predefined pressure, protecting them from low pressure conditions.

The VIGIA system is installed in the vehicle. It is a visualization and calibration unit located in the cabin supplied by direct 24V. It contains an compressed air inlet coming from the boilers of the vehicle and two calibrated outlets with an integrated pressure gage that goes to the tyres of different axis.



The air inlet through a tire valve installed in the axis is made by a slip ring in a way that there are no air leaks while the tire rolls.

3.- OBJETIVE OF THE TRIALS

The objective of the following trials is to certify that the equipment accomplishes its assignments by comparing a tire being supervised by Vigia and another one that is not; after different trials made in this laboratory and under the conditions described later.

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4.- EQUIPMENT PROVIDED BY THE APPLICANT

The equipment provided by the applicant for the trial is a sealed package containing:

- o . 1 display / calibrator equipment
- o . 4 slip rings
- o . Piping to be installed on 2 independent axis
- o . Valve connections
- o . Wheel covers to hide the system

The package is opened in front of the applicant in INSIA plant.

5.- TRIALS TO BE MADE

The trials last about 1.5 weeks during which 4 comparative tests are made between two tires::

- . Brand: Michelin
- . Model: XDA 2+ Energy
- . Size: 315/80 R22.5
- . Manufacturing date: 0710

Both tires are new with 0 Km. Both are assembled in INSIA, with equipment and rims from this laboratory. The assembly is detailed in the following section.

The objective of the trials is detailed below:

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. Test 1: Proving that the temperature and pressure are the same in both tires under the same conditions.

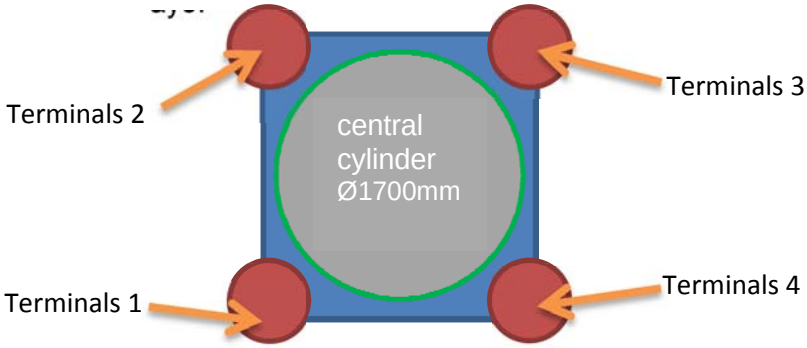
. Test 2: Proving that the VIGIA equipment increases the pressure up to the rated pressure in the supervised tire being cold and warm.

. Test 3: Simulation of a puncture in both tires and response of the VIGIA equipment.

. Test 4: Robustness of the equipment under an homologation R54 testing..

6.- EQUIPMENT USED

A tire test bench of INSIA is used to make these trials. This bench fulfills every prescription of Regulations 54 and 109 and it consists of a central roller of 1700 mm of diameter and 4 testing terminals where the rim is assembled with the testing tire.



The tire strength is applied against the roller through some flanges or pneumatic blowers of double lobe installed from behind the radial tire to the central cylinder.

The turning speed is applied through an electrical engine installed in the central cylinder; when this cylinder turns, its surface and the tire surface have the same lineal velocity in the tread.

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Besides, the pressure will be controlled analogically with the VIGIA equipment and digitally with two sensors of pressure supplied with 24 V and a KELLER brand 0-25 bar scale, model PR-21.

These sensors will be installed in the control room of the trial and as close as possible from the VIGIA equipment in order to have the best and precise measure about the functioning of the system and with no delays.

These trials imply knowing the temperatures generated in tires, both in tire shells and in the treads; all of them during this trial.

This is necessary to know the relation between pressure and working temperature.

For this, a thermographic camera, model Thermacam 2000 of FLIR systems has been used property of INSIA. This camera was calibrated to measure the temperature on rubber with an emissivity coefficient c_e=1

This camera was installed on a metallic cage inside the tire cell; in order to avoid possible strokes due to unexpected tire failures. The complete cabling was taken to the testing control area.

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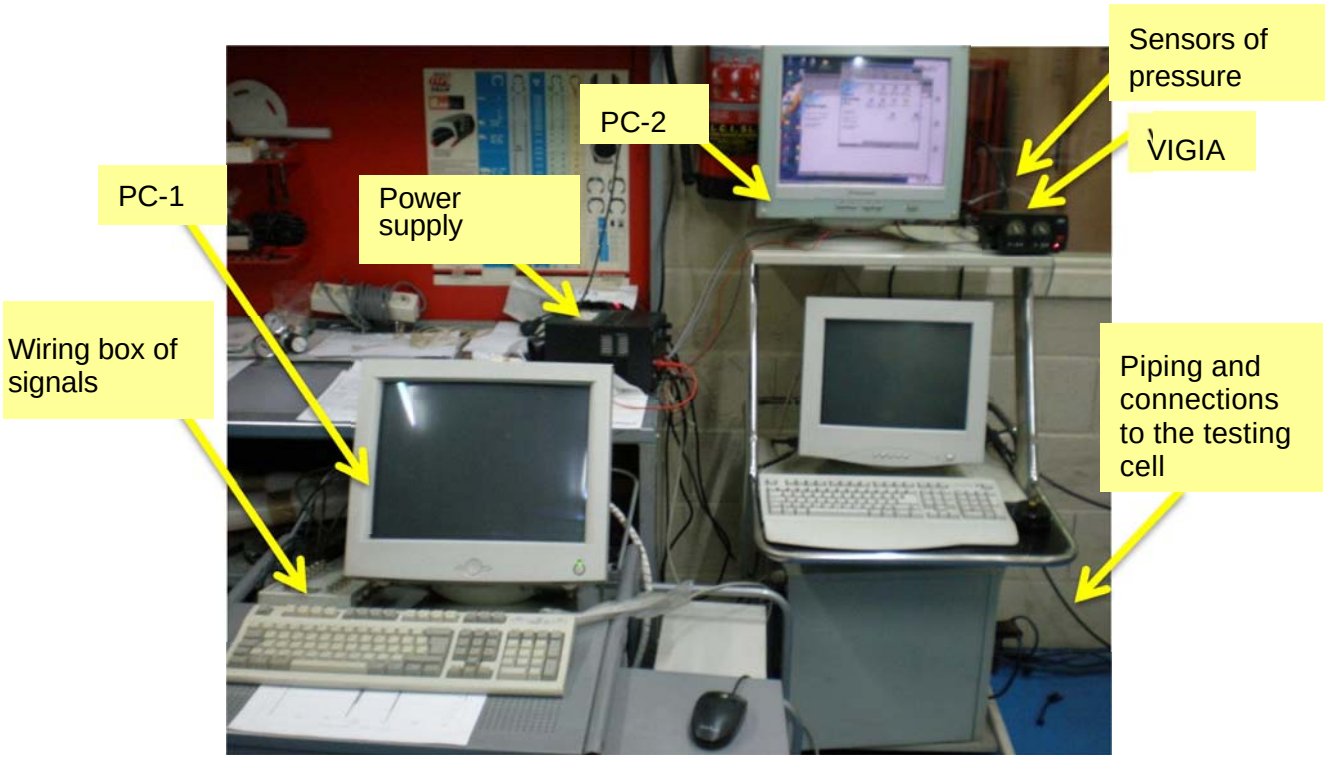
In the control area, we have installed:

- Power supply of 24 V to feed the sensors of pressure and the VIGIA equipment.
- PC-1: signals coming from the trial:
  . Pressure 1
  . Pressure 4
  through the mentioned sensors.
  . Tire strength 1 on the cylinder:
  . Tire strength 4 on the cylinder
  signals from the loading cell that controls the pneumatic flanges.
- PC-2: signals coming from the thermographic camera: temperature of the testing image.
- Compressed air system to supply the VIGIA equipment, coming from the boilers of the vehicle.



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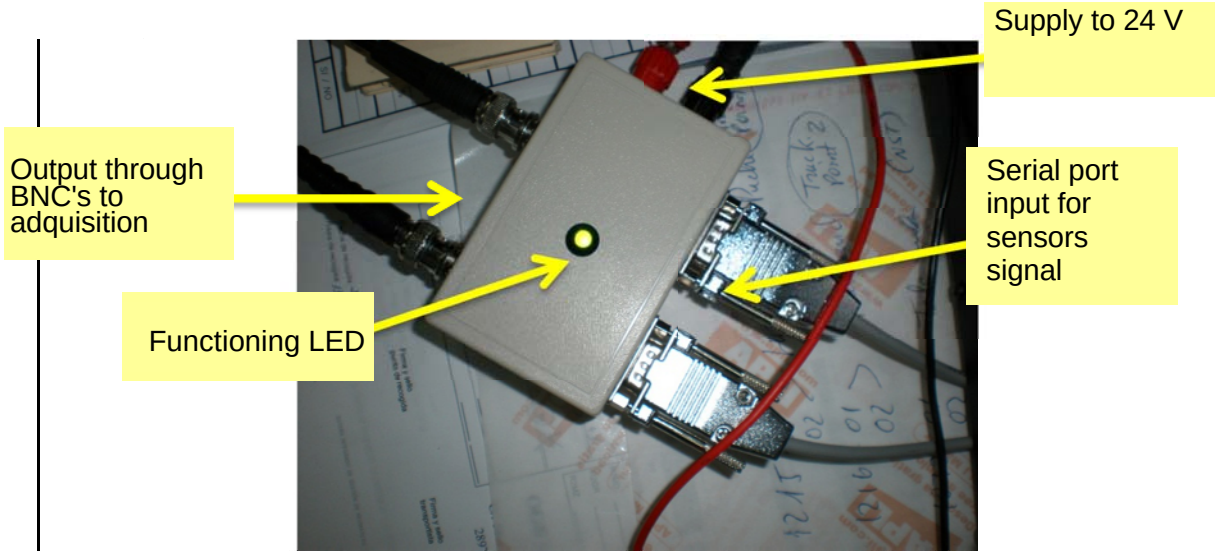
To make the wiring for the signals coming from the pressure and strength sensors applied to the tire, a connection box is used through BNC's that INSIA has and which is correctly tested.

Channels 9 and 10 will be used to get the pressures from 1 and 4 respectively and channels 11 and 12 to get the strength 1 and 4 applied to the tires.



This connections box has been made because the pressure sensors should be supplied with power.

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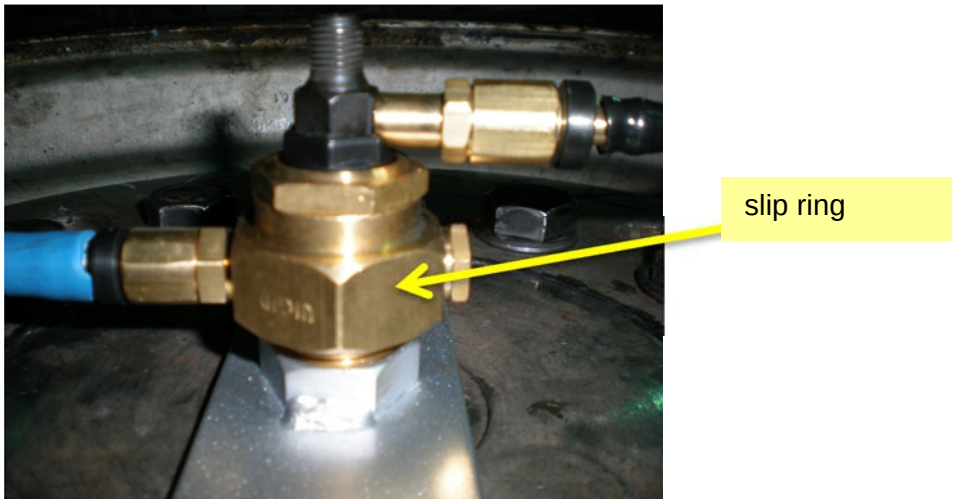
7.- SETTING FOR THE TRIAL

When client brings the tires we control that they have the same characteristics, manufacturing date, etc. We also check if they are deteriorated, used or any other detail that may imply a failure in a tire.

We assemble the tires with the rims and inflate them with 8 BAR of pressure and stabilize them. On the following day, we check if they still have the same pressure.

Then, we locate them in terminals 1 and 4 of the testing machine as shown below:

A slip ring is used to connect to the pneumatic system, together with the tested equipment.



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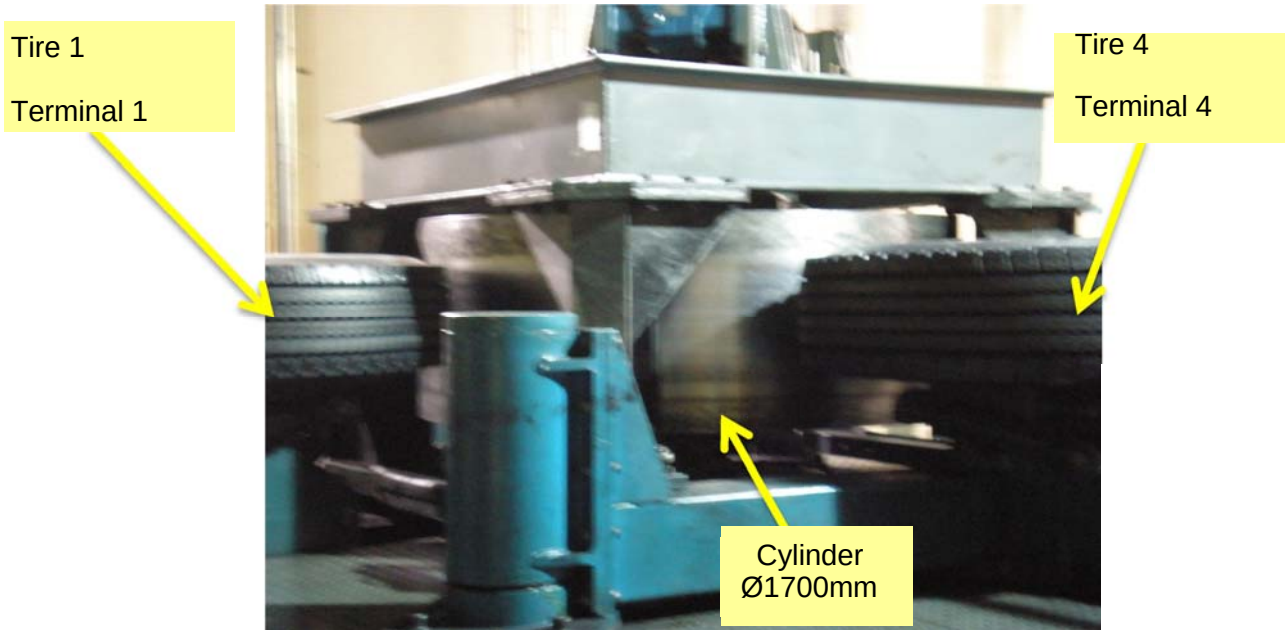
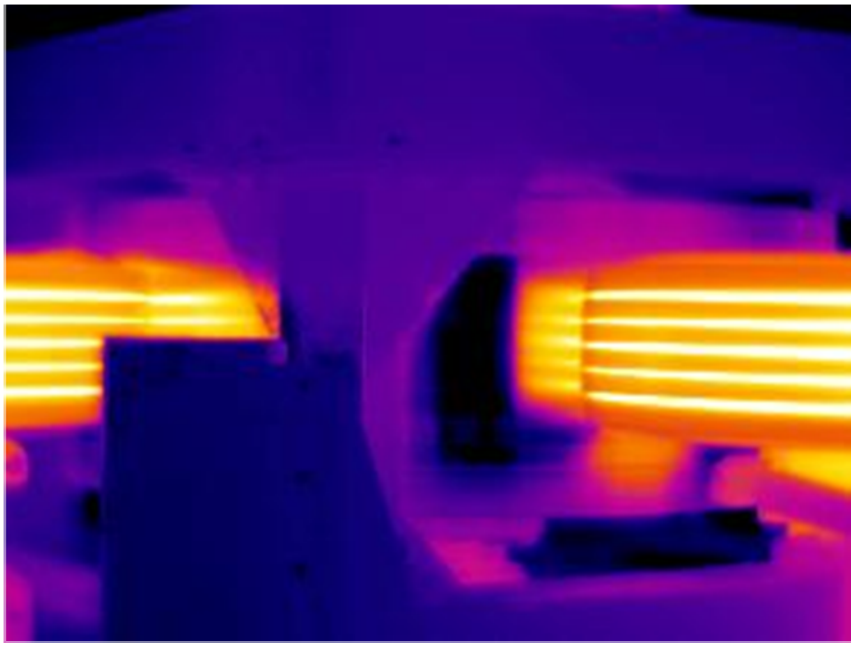
For every trial to be made, we decided that tire Nº 4 should be supervised by the VIGIA equipment and Nº 1 should not have any supervision. In the control room, we connect both tires to a valve by removing their howitzer in order to simulate a puncture calibrated through a valve.

We set the thermographic camera in a way that the infrared image covers the following area:





Note: Thermal imaging acquired during one of the trials.

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8. RESULTS OF THE TRIALS

Trial 1:

The first trial was made on Tuesday 23rd. of November, 2010. The aim is to compare the evolution of strengths, temperatures and pressures applied of both tires under the same conditions in order to assure that the results of future trials will be reliable.

Preparing the sample

Both tires are assembled to the rims according to the previous article. They are inflated with 8 BAR each and are put to rest.

Climate conditions

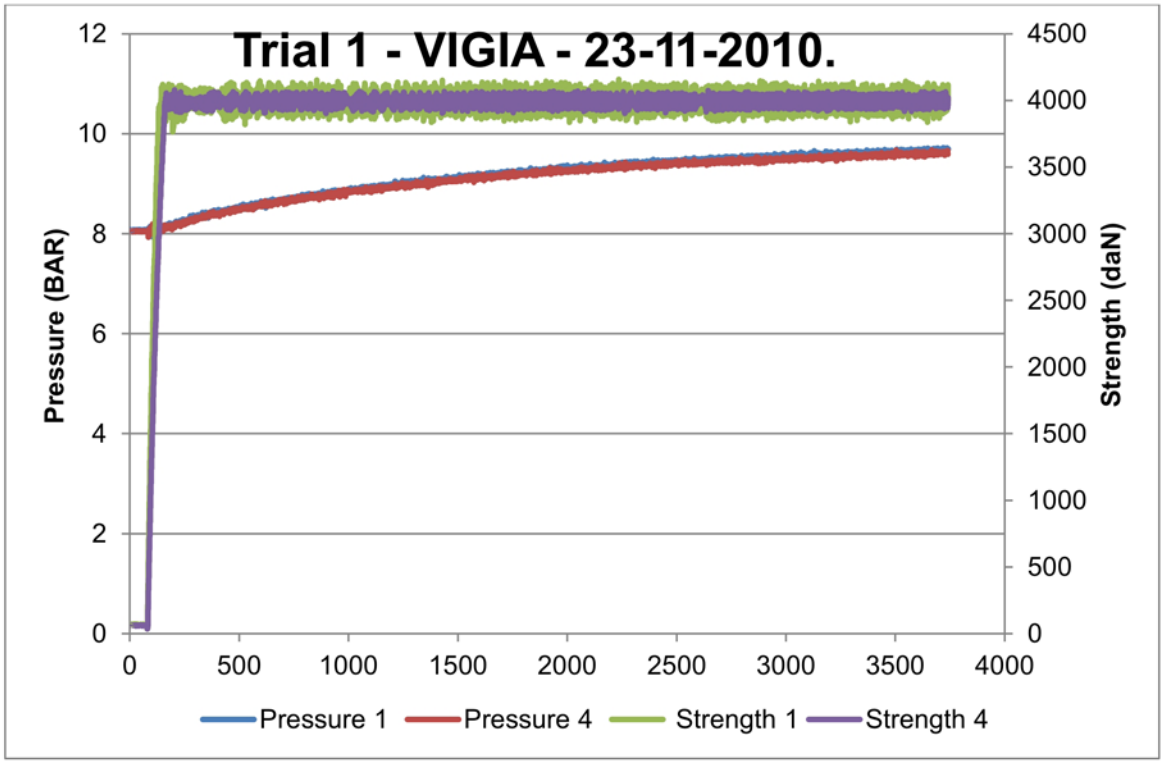
The temperature of the room is set at 18º C during 24 hours.

Starting of the trial

The testing begins at 11:00 hr. applying a strength of 4000 daN on each tire and a velocity of 200 rpm on each roller such as the standard says (R54) for charging and velocity of tires.

The trial lasts an hour under stable conditions obtaining the following results:

Result:



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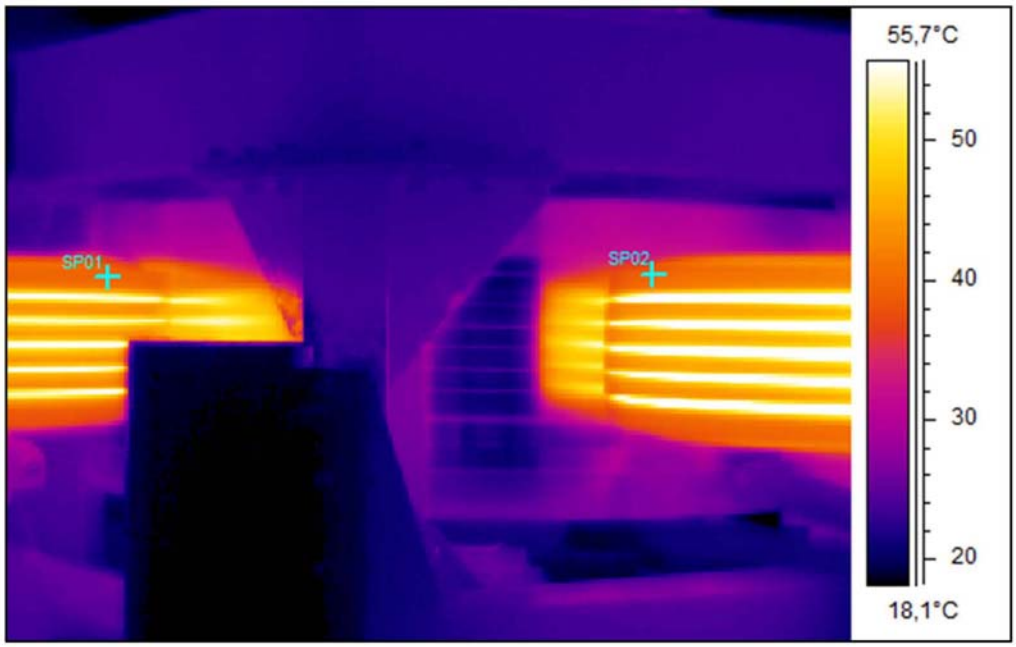
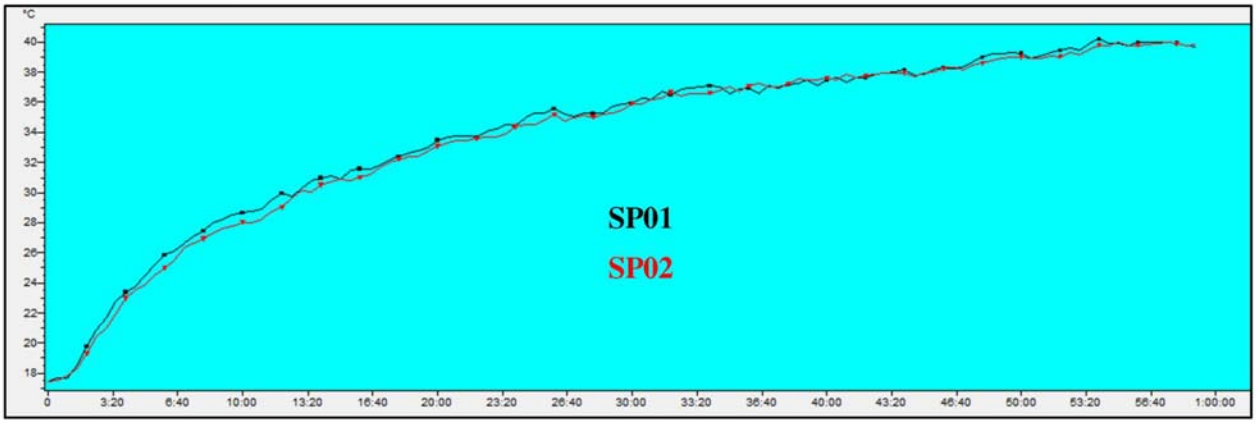
In the previous illustration we can see the evolution of pressures and the strength applied on both tires.

In the following illustration we can see the final thermal imaging of the trial and the evolution of temperatures in both treads.





We check that both, pressure and temperature, are stable and their differential worth tends to be 0, by which we continue with the trials.

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Trial 2:

On Wednesday 24 of November, 2010 and once we confirmed that the results of the previous trial had identical conditions, the second trial takes place. Its aim is to check the functioning of the VIGIA equipment under different circumstances. Firstly, we verify the evolution of pressures and temperatures in both tires starting from tire 1 (not supervised) inflated with a pressure of 7 bar, while tire 2 starts with a pressure of 8 bar. Since then, several situations take place.

Preparation of the sample

Both tires are stabilized. We inflate tire 4 with 8 bar and tire 1 with 7 bar.

Climate conditions.

The temperature of the room is set at 18º C during 24 hours.

Starting of the trial.

The testing begins at 11:30 hr. applying a strength of 4000 daN on each tire and a velocity of 200 rpm on each roller such as the safe working load and speed of tires allows.

The trial lasts 1.5 hours under stable conditions:

Afterwards, we provoke an air loss of 1 bar in both tires and then continue with the trial for half an hour.

After 30 minutes, we provoke another air loss in both tires so the VIGIA equipment starts working and we verify its functioning.

Results.

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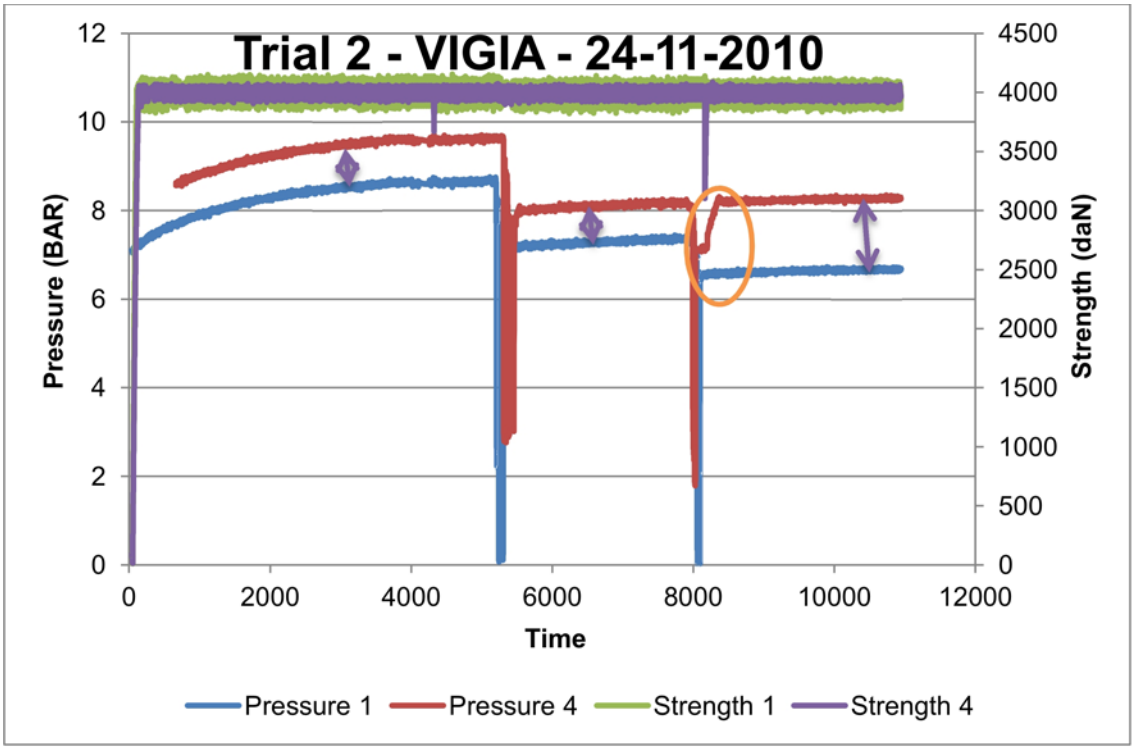

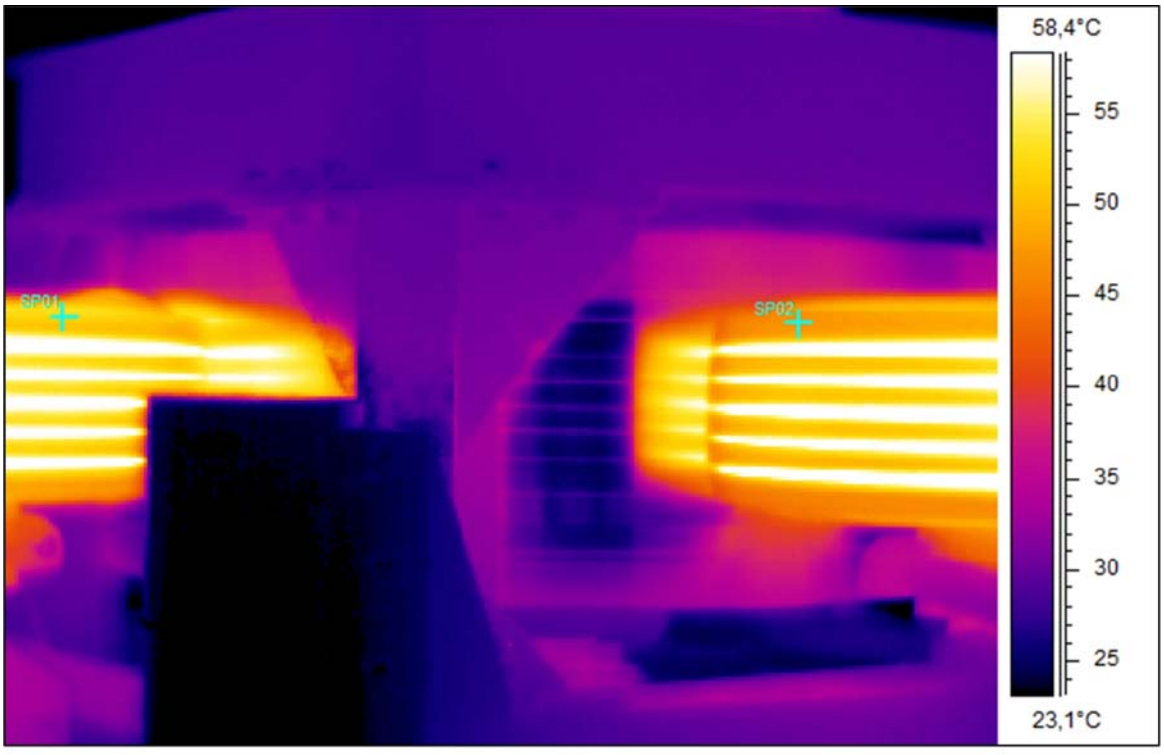

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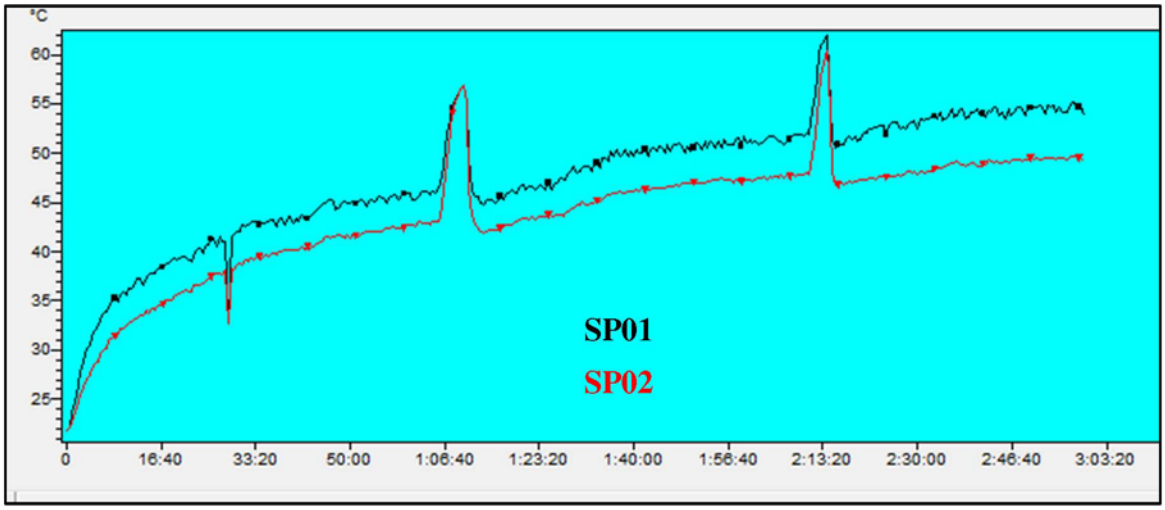
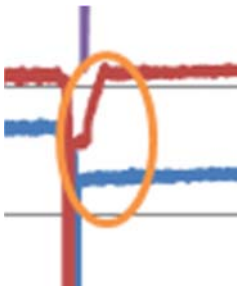


The thermal illustration shows the evolution of temperature in both tires; the difference between them is bigger as the pressure difference increases, so when the pressure is low, the temperature gradient increases.

The peaks we see in the graphic have an explanation. On the one hand, we stop the trial and the temperature in the tread increases because there is no dissipation due to the velocity and contact with the air; on the other hand, when the tire is emptied there is internal turbulence increasing the temperatures. When we begin the trial again, the temperatures normalize and the halo of heat around the tire disappears due to the aerodynamic of the wheel, this is why the temperature decreases to normal values.



During the third stage of the trial and after 2.15 hours we release air from tire Nº 4 until the VIGIA equipment starts to function, increasing the pressure up about to 8 bar. The difference of temperature between both tires is more notorious during this stage.

After 3 hours, we stop the trials for 20 hours so the thermal condition of the tires normalizes before starting the next trial.

Trial 3:

On Thursday 25 of November, 2010 after the thermal stabilization of the previous trial, the third trial takes place. Its aim is to test the functioning of the VIGIA equipment when there is a puncture. First we check the evolution of pressures and temperatures in both tires starting from tire Nº 1 (not supervised) and Nº 4 the remaining pressure provoked by the cooling from the previous trial. Then, we normalize both pressures at 8 bar and provoke a calibrated puncture in both tires. The evolution of pressures and temperatures are analyzed.

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Preparation of the sample

On the 25 of November, tire Nº 1 has 5.2 bar while tire Nº 4 has 6.5 bar and at ambient temperature.

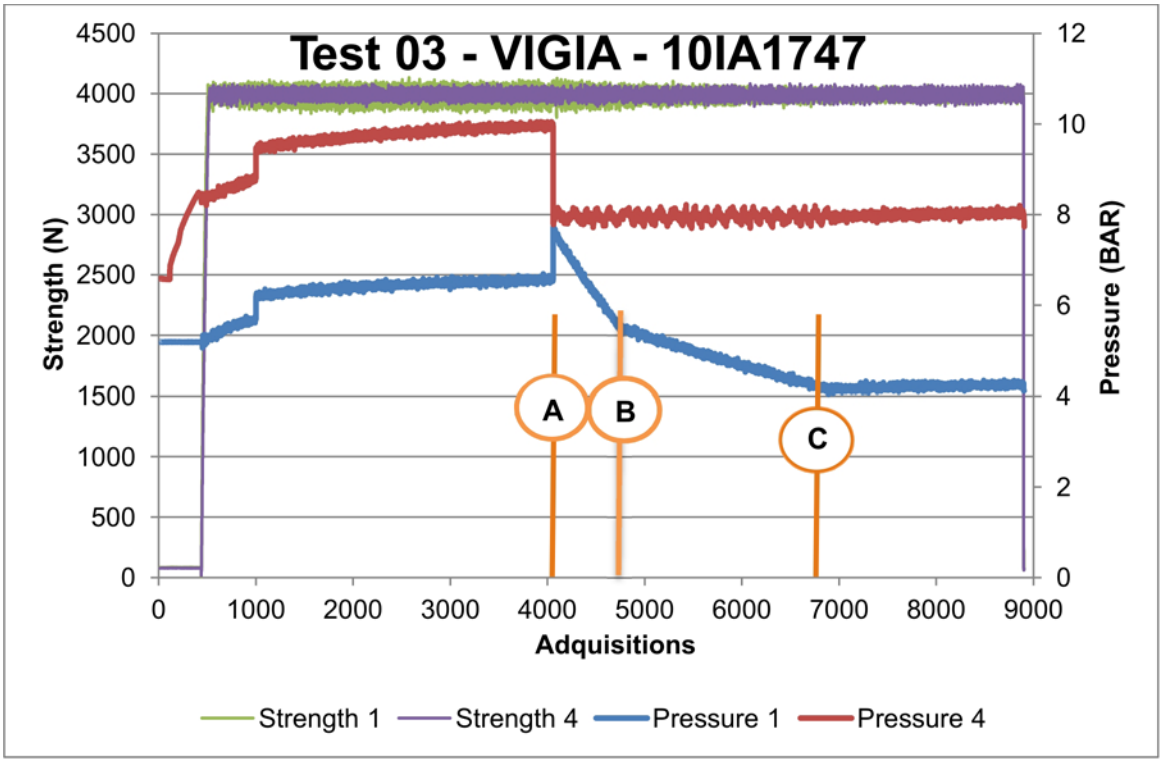
Climate conditions

The temperature of the room is set at 20º C during 24 hours.

Starting of the trial

Before starting the trial, we connect the VIGIA equipment just like when we start the vehicle and wait until it warms up before driving it. From this we obtained that tire Nº 4 that was below the pressure measured in the equipment, inflates up to its rated pressure. Since then, we begin the trial.

Result.



After an hour of testing and with no interruptions, both tires increase to 8 bar as if the driver knew that the tires had low pressure and stopped to calibrate them. (A)
Since then and with a valve calibrated in the control room, we provoke a constant air loss in both tires.

While pressure from tire Nº 1 decreases drastically, tire Nº 4 gathers pressure constantly originating the "saw teeth" from the picture. Besides, the display of the VIGIA equipment warns the driver that the tire is having problems, while tire Nº 1 has no warning signals at all.

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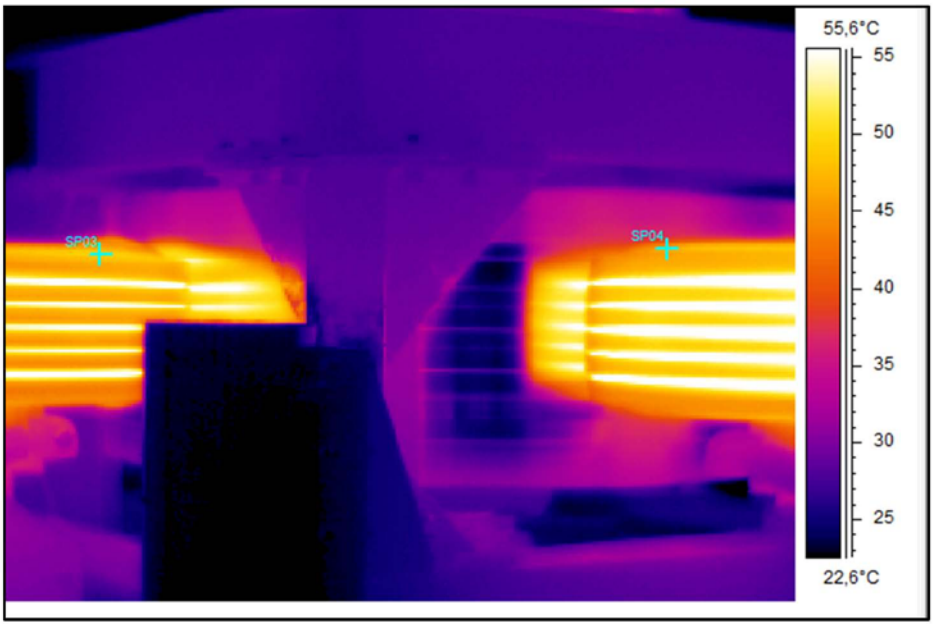
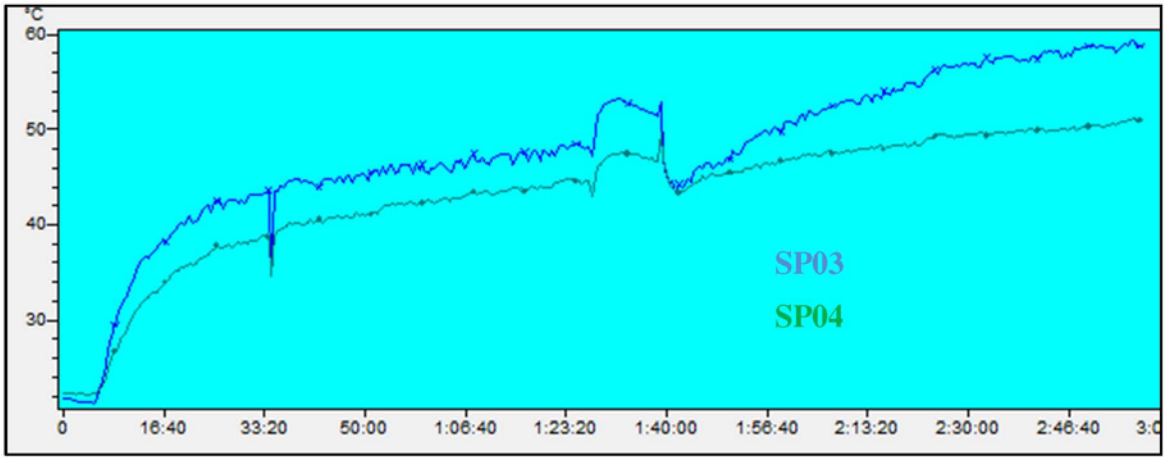
After a while, we readjust the spitter valve from both tires since we know that we will be with no pressure before time, which means a drop of the blue line corresponding to tire Nº 1 in graphic (B).

After about 2 hours since the puncture, both valves are closed completely to protect tire Nº 1 due to critical functioning conditions. (C).



In the thermal image we can see how tire 1 has a higher flank deformation than tire Nº 4.



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The evolution of temperatures from the beginning of the trial until the stabilization of pressures is similar to the previous trials. Since 1:40:00 pressures stabilize and that also produces a temperature stabilization.

As the puncture moved forward in tire 1, it is more evident the difference in temperature of both tires reaching a breach of 10º C in only 1:20 hr.

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Trial 4:

On Tuesday 30 of November, 2010, the last trial using the VIGIA equipment is made. This trial consists of a durability and hardiness testing of the system facing a hard homologation test according to R54 which lasts 47 hours. The trial consists of three stages of increasing loading. The values for the trial will correspond to the tire being tested.

Preparation of the sample

Both tires receive 6 bar of pressure and they are left for a complete weekend for its pressure stabilization.

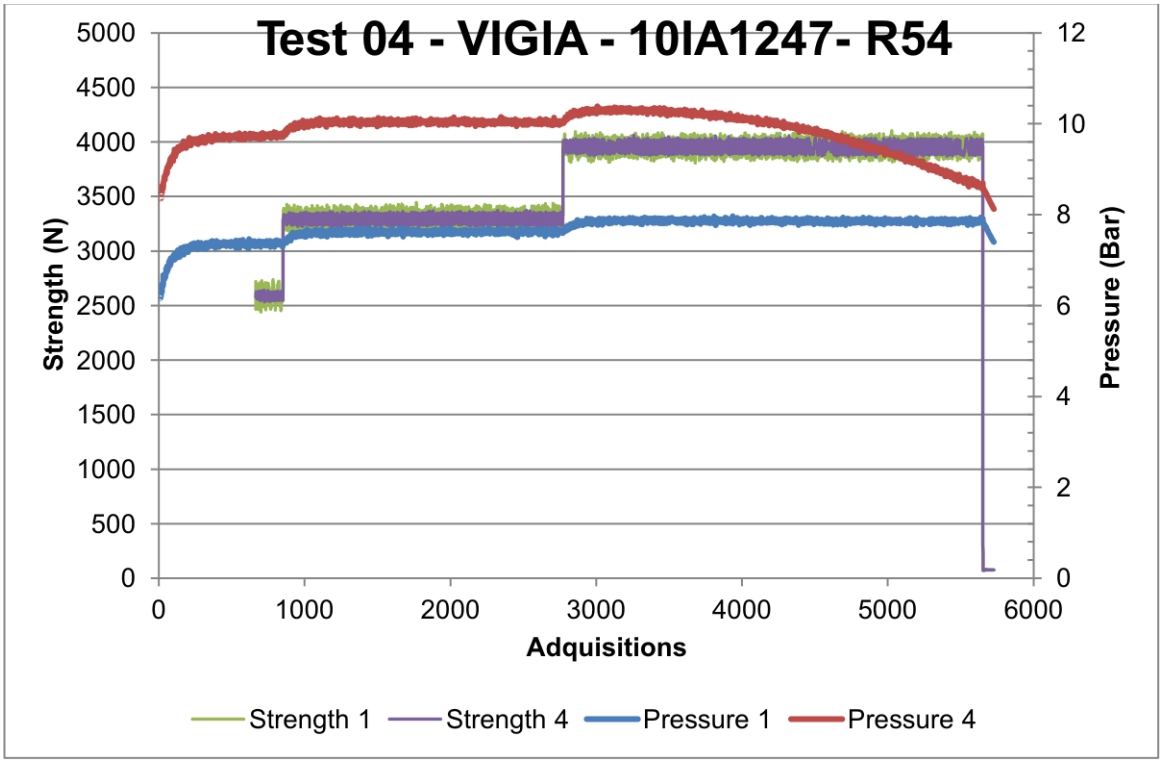
Climate conditions

The temperature of the room is set at 20º C during 3 days.

Beginning of the trial

Before starting the trial, the VIGIA equipment is connected just like the previous trial. The result is that tire Nº 4 that had a lower pressure than the measured one in the equipment, inflates to its rated pressure. Since then, the trial begins with tire 1 at 6 bar and tire 4 at 8 bar.

Result:



During the third stage, a little air loss is provoked in tire 4 which was ignored just because the system will keep the pressure at 8 bar. After finishing the trial, the tire is still with 8 bar whereby the equipment did not have to act.

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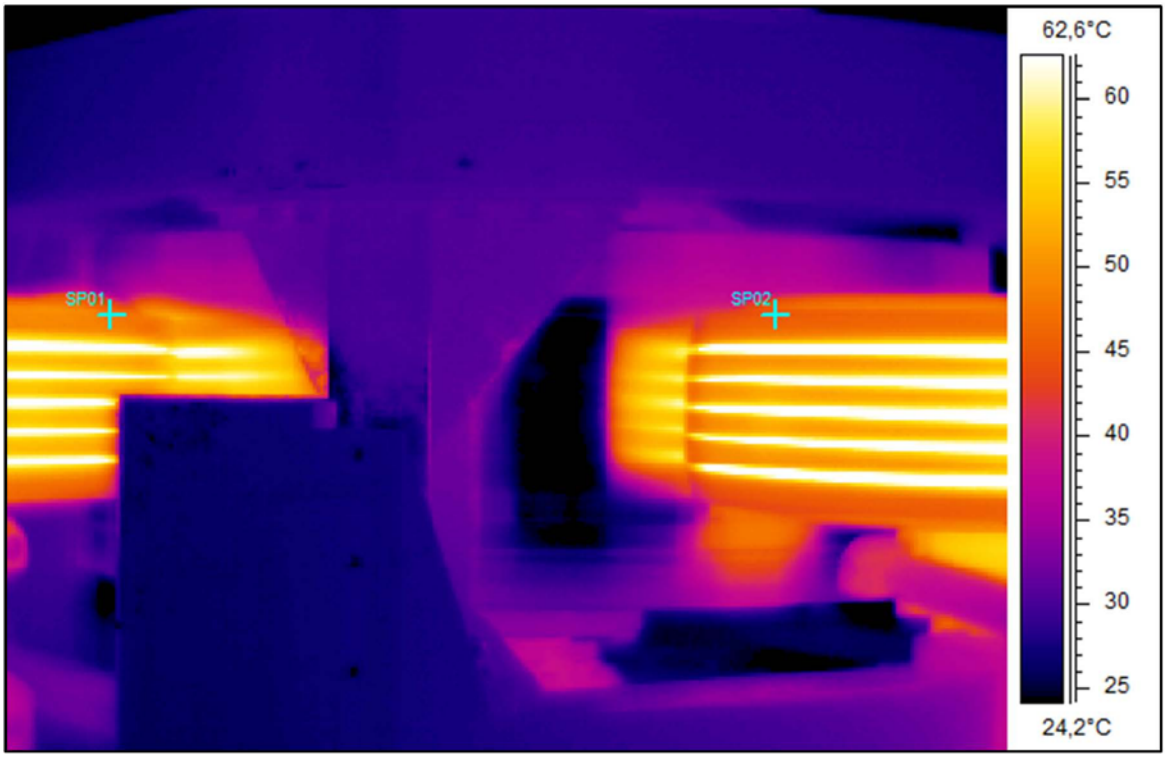
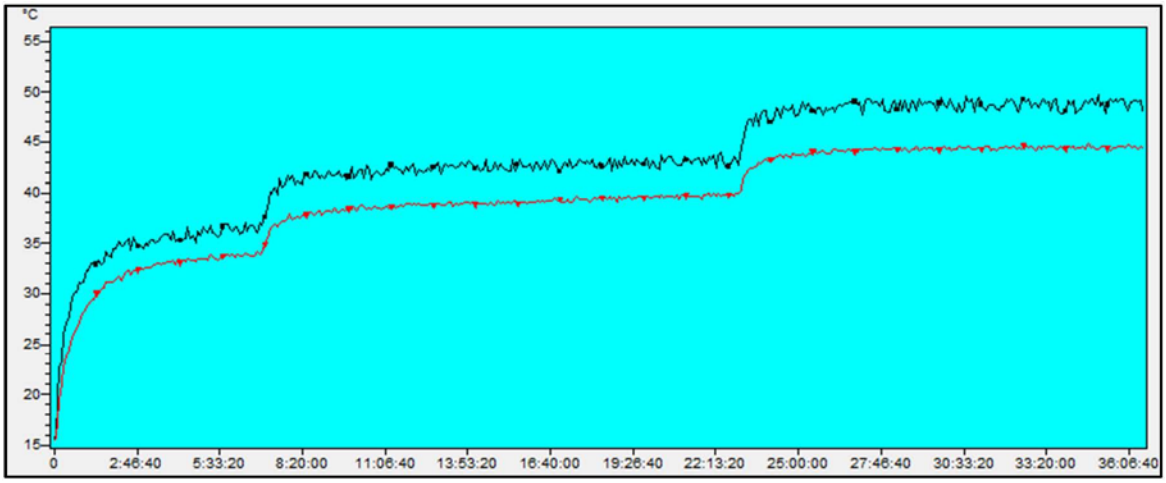


In the graphic, the temperature in both tires keeps the outline of pressure, just like previous trials. Obviously, the tire with less pressure suffers the increasing of temperature due to the flank and tread deformation.



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9. CONCLUSIONS

The VIGIA equipment does not allow that the pressure from the supervised tire to decrease under the pressure set by the user when using the vehicle.

When the vehicle starts, the VIGIA equipment restarts the pressure of the tires to the pressure set by the user.

By keeping the best pressure in both tires, the VIGIA equipment avoids a higher warming up and a deformation of the flank, which increases the lifetime of the tires. (see appendix I)

During the trails, the VIGIA equipment remain airtight. This airtight is doubly secured since the trials were made with no howitzer in the inflation valve and during its normal use, this will be put in a way that it will work as an unidirectional valve which assures the airtight of the tire together with the VIGIA equipment.

We can also conclude that by keeping the correct pressure in tires using the VIGIA equipment, fuel consumption of the vehicle decreases and at the same time the weathering of the tires is optimized according to their manufacturer (Appendix I)

The VIGIA equipment warns the driver when a tire losses air.

According to the recommendations of the Traffic General Administration, keeping the correct air pressure in tires (by using the VIGIA equipment) implies more security when driving.

The functioning of the VIGIA equipment is not modified during the trial foreseen in Regulation 54 about load-speed for the homologation of the industrial tire.

Approval	Made by	Revised by
José María López Martínez Director of the Homologation and Trials department	**Rodrigo Encinar Martín** Trials technician	**Susana López Sánchez** Technician Director of the Vehicles and Components Laboratory

Madrid, 19th of January, 2011

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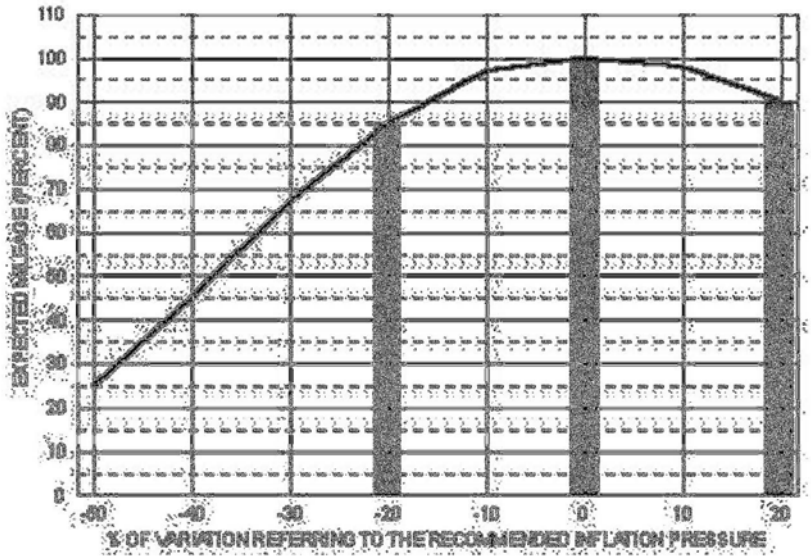
Appendix I (manufacturer's recommendations)

Inflation pressure

Tires are the only contact point between your vehicle and the surface. The inflation pressure is very important which affects the driving security, the mileage and fuel consumption. A lower or higher pressure than the appropriate one, may have negative influences on the tire's performance: so, it is very important to keep the correct pressure in your vehicle.



The "suggested inflation levels" do not exist. The correct inflation value is determined by the manufacturer and can be read in the manual of the vehicle. To verify the pressure of each tire, they must be cold. Tires are considered to be cold when they have not been moving for at least an hour or if they have rolled no more than 2 or 3 kilometers at low speed. Often verify the pressure of cold tires (at least once a month), always do it before travelling. Never forget the spare wheel!

Last version: 05-07-2007. Source: Pirelli (http://www.pirelli.es/web/technology/about-tyres/tyres-advice/car-tyre-infl/default.page)

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CHECK THE PRESSURE EVERY MONTH

The correct pressure reduces the risk to loose control of the vehicle. It also protects the tires from a premature wear and irreversible internal damages. Tire pressure may also decrease due to small holes, because of the natural escaping of air though the tire components or even due to the low ambient temperature. The tire pressure must be checked every month and before travelling, including the spare tire, preferably with the tires cold (less than 4 kilometers of rolling at low speed). If the pressure is checked in warm, it is recommended to add 0.3 bar of pressure. It is very important to check the pressure once a month because:

- Low pressure increases the risk of damaging the tires
- An overpressure of 20 % reduces the lifetime of the tire
- A correct pressure increases the lifetime of the tire and it saves overfuelling

The recommended pressure does not appear in the tire. The inflation pressure that appears in the lateral of the tire is the maximum inflation pressure. The recommended inflation pressure can be found in:

- The user manual
- On one side of the door, together by the driver's seat
- Inside the door trap of the fuel's deposit

Source: Michelin (http://www.michelin.es/neumaticos/consejos/guia-de-mantenimiento/diez-consejos-neumaticos)

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FUEL SAVING

Which consumption proportion can be attributed to the tires?

Fuel consumption depends on several factors. To begin with, there are 4 types of resistances when driving that affect the consumption:

Tread resistance (tire inflation / loading of the axis, tread design, rubber components)

Resistance to climbing slopes and to acceleration (geographical conditions, driving styles)

Air resistance
(contact surface with air)

Resistance to an unload driving
(mechanical resistance, for example, when driving with no loads, it can be ignored due to a prevalent driving)

Tread resistance causes between the 35% and 60% of fuel consumption. This value varies depending on the number of tires. Obviously, this is a starting point if you want to save money in diesel, each day more expensive.

Tread resistance and axis position

Tread resistance proportion with respect to the axis position corresponds to the loading weight proportion towards the position of the axis (direction, driving and loading wagon):

The result is that tires from a tractor wagon offer a better saving potential.

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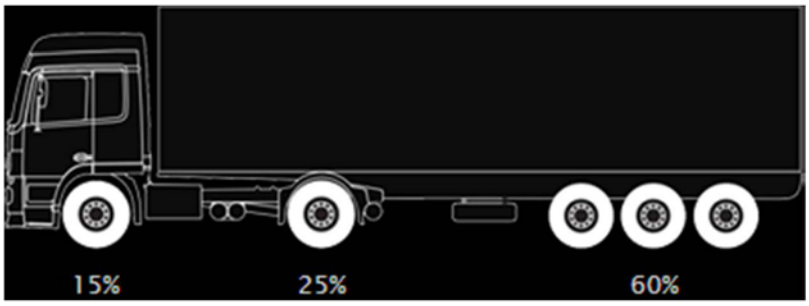

The result is that tires from a tractor wagon offers a better saving potential.

What is the rolling resistance?

Rolling resistance is the strength performed by the moving tire over the pavement when travelling loaded (deformation energy in tires and in pavement)

What can be done to decrease fuel consumption?

There are several ways of saving fuel: for example, the way of driving, the air conditioner and the correct engine calibration.

The most important measure to save fuel consumption with tires are:

- Use low tread resistance tires, such as those developed by the engineers from Continental.
- Avoid low pressure (tires with low pressure = high resistance to rolling) for example, controlling regularly the fleet by the service disposed by Continental to their customers.

- Keep the tires within the geometrical parameters of the axis so they would just roll and not "slide" due to a wrong displacement.
- Speed increases disproportionately the rolling resistance. Be careful not to drive too fast with no reason. Rolling resistance and, therefore, fuel consumption, is bigger with a higher medium speed, because tires roll with more frequency during certain time, that is to say, tires are most of the time deformed.

Source: Continental (http://www.contionline.com/generator/www/es/es/continental/transporte/temas/goods/fuel_saving/fuel_saving_tips_es.html)

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