Universidade de Brasília (Brasília University) Faculdade UnB Gama (UnB Gama Faculty)
Dynamic Metrology Laboratory Work Order NO 087/2011

Brasília, December 9th, 2011

Product Certification – CENTRAMATIC Self-Balancing Device

Project: CENTRAMATIC Self Balancing Device performance evaluation when installed in cargo[?] vehicles.
Responsible Institution: Universidade de Brasília, Faculdade UnB Gama, Automotive Engineering, Área Especial de Indústria Projeção A, Setor Leste, 72444-240 Gama, DF
Tests Initial Date: 17-03-2011
Test Location: Centro de Ensino e Pesquisa em Segurança Veicular – CEPSV – accredited by INMETRO as an inspection institution in the vehicle safety field.

The Universidade de Brasília – Faculdade UnB Gama was hired by SONOVA Ltda company to evaluate the performance of the wheel self-balancing device named Centramatic on tire wear and axle/wheel/tire system vibration in road vehicles. A partnership was made with Real Expresso Ltda. company which agreed in making available two interstate route buses from its fleet to participate in the field and laboratory (Vehicle Inspection Line) tests.

The self-balancing device is made of a circular plate (to be mounted in the vehicle) in whose external diameter there is a tubular ring attached, in the interior of which there are spheres immersed in a synthetic fluid. This product can be mounted in either the front axle or the rear axle (between wheels), changing only the assembly configuration, without changing its working principle. During the wheel spinning, the centrifugal force makes the self-balancing weights inside the ring distribute themselves in order to balance the wheel/tire assembly.

For the product certification, two buses of the Marcopolo brand were used: one with the self-balancing devices installed in all axles and the other without the device. The field tests lasted for 6 months, which resulted in an average travel distance of 81,750 km per vehicle. During this time, data collection was performed monthly at the Finatec Vehicle Inspection Line, presently located in the UnB-Darcy Ribeiro Campus. Besides the data acquired regarding tire wear, tests were performed to measure the axle/wheel/tire assembly vibration level. For the vibrations tests, it was necessary to perform the tests with and without the self-balancing device installed in the same vehicle. Figure 1 shows one of the buses at the vehicle inspection line and the self-balancing device installed in one of its front wheels.

Figure 1. One of the buses used in the tests and the self-balancing device installed in one of its front wheels.

Standard Measurement Systems:

Digital Calibrator: FLUKE 5500A identified by serial number 8415917
Calibration Certificate no. CCR 033/06 – LACTEC/RBC INMETRO

Reference Technical Standards List:

NBR 6690-1996 – Electrical Measurement Instruments Test Laboratories
NBR 6509-1996 – Electrical and Electronic Measurement Instruments

The equipment used to measure the tire wear was [a] digital depth gauge, besides visual inspection. For the vibration analysis, an instrument chain made of accelerometers and a B&K signal conditioner, NI A/O acquisition card and a notebook, was used.

1. Axle/Wheel/Tire System Vibration

To collect the vibration data with and without using the self-balancing device, two accelerometers were attached (by means of magnetic bases) to the wheel axle, both in the same longitudinal position along the axle, however in orthogonal directions. The accelerometers were attached to the rear axle due to limitations in the inspection line. A total of 5 tests were conducted. In each test, the vibration data were acquired for different speeds set to the vehicle (20 km/h, 40 km/h, 60 km/h, 80 km/h).

Table 1 Vibration Reduction

Vehicle Speed	Vibration Reduction
20 Km/h	16%
40 Km/h	35%
60Km/h	31%
80 Km/h	59%
90 Km/h	34%
110 Km/h	36%

Table 1 shows the results regarding the vibration reduction when the self-balancing device is used.

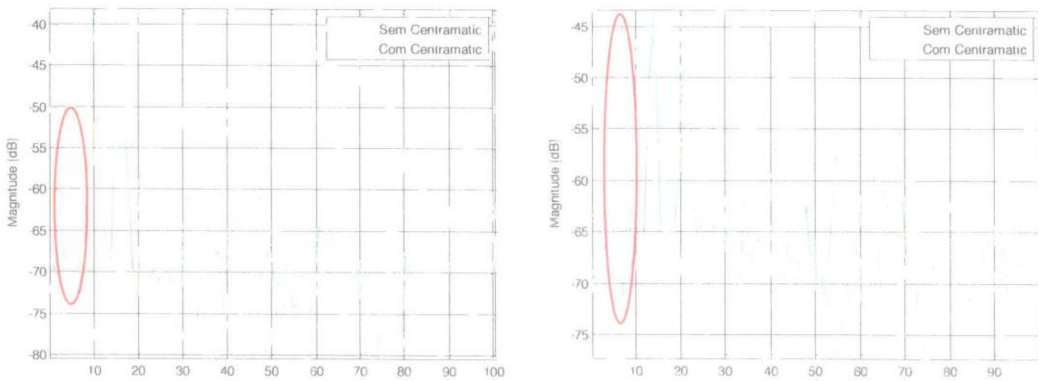

Figure 2

exhibits two acceleration spectra to better visualize the vibration reduction in the wheel/tire assembly axis rotation frequency. Observe the difference in the values of the marked peaks. It must be pointed out that the scale used in the vertical axis is such that safeguards the company’s technical information.

Vehicle Speed / Vibration Reduction

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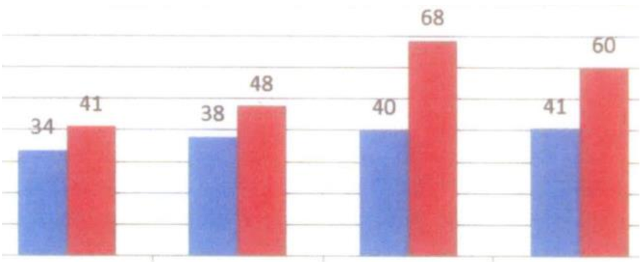
[Charts]
[vertical axis:] Magnitude [Amplitude?]
[horizontal axis:] Frequency (Hz)
[Box:] without Centramatic, with Centramatic
Figure 2 – Vibration Spectrum for the 60 Km/h and 80 km/h Speeds.

2. Tire Wear

In these tests two buses were used, only one of which was equipped with the Centramatic self-balancing device. During the inspections, carried out between March 17th and September 1st, the internal, intermediate and external grooves depths were analyzed for all tires of both buses. Figure 3 exhibits a wear comparison for the tire sets of both buses. It is important to highlight that the self-balancing device equipped bus travelled 17,500 km more and even so its tires wear was significantly less than the bus without the device. A special attention must be focused in the rear axle tires, where the wear reduction was very important.

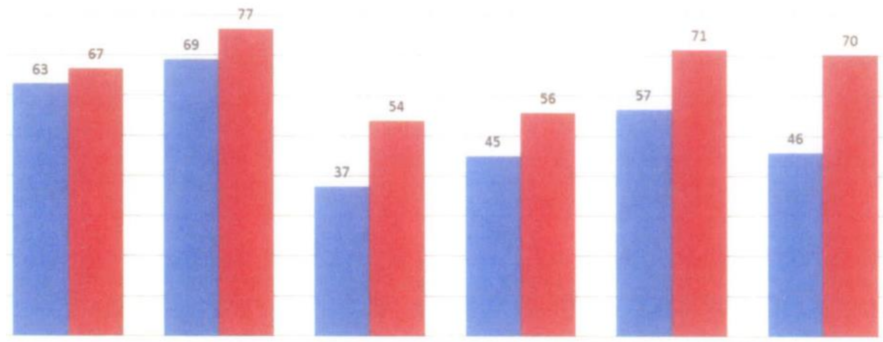


tire 1 tire 2 tire 3 tire 4

Tire Wear Evaluation
[Bar Chart]
[vertical axis:] Tire Wear (%)
[horizontal axis:] tire # 3, tire # 4, tire # 5, tire # 6
[blue box:] Bus without Centramatic (97,595 km travelled)
[red box:] Bus with Centramatic (115,095 km travelled)
Figure 3 – Tire Wear Chart for Sept 1st

Although the vehicle equipped with the Centramatic balancing devices has travelled 17500 km more, it presented a tire wear savings in order of 41.83%. It is important to highlight that in this test set the tires # 1 and # 2 grooves were not measured because these were replaced.

In order to have a comparison among all tires, it was chosen to present a wear chart related to a measurement carried out in the period before the one presented in Figure 3. A bar chart more general where it was considered the wear of the 6 tires during the period from March 17th to July 21st is presented by Figure 18[?]. Again it is highlighted a reduction more significant in the bus rear tires, but one cannot overlook that the device also reduced the wear in the front tires. Another factor of important relevance consists in the fact that again the bus equipped with the self-balancing device travelled approximately 10,000 km more than the bus without the device, and even so, had less wear in its tires sets.



Tire Wear Evaluation
[Bar Chart]
[vertical axis:] Tire Wear (%)
[horizontal axis:] tire # 1, tire # 2, tire # 3, tire # 4, tire # 5, tire # 6
Tire position in the Bus
[blue box:] Bus without Centramatic (72874 km travelled)
[red box:] Bus with Centramatic (82501 km travelled)
Figure 3 – Tire Wear Chart for the period from March 17^{th} to July 21^{st}

Although the Centramatic self-balancing devices-equipped vehicle having travelled 10,000 km more, even so it presented a tire wear savings in the order of 24.60%. Comparing Figure 3 to Figure 4 it is possible to state that Centramatic self-balancing devices efficiency increases when the mileage travelled by the vehicle also increases. This statement is supported by comparing the tire wear measured data in the initial phase to the data in the final phase, which turned out savings of 24.60% and 41.83%, respectively.

3. Conclusion

Therefore, the present document attests the efficiency of the self-balancing device for increasing the tires service life and in the reduction of vibration transmissibility in road vehicles supported in the data acquired in the test field.

The fuel consumption was monitored along the certification test, resulting an average 1.5% consumption reduction in the vehicle with the self-balancing device mounted.

[signatures]