

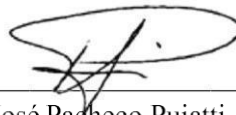
TEST REPORT

DETERMINATION OF THE INFLUENCE OF GREEN PLUS CATALYST  
ON ENERGY EFFICIENCY IN TRANSPORT VEHICLES



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## 1.- INTRODUCTION

This test report presents the activities performed and the results obtained during the determination of the influence of the Green Plus catalyst in the energy efficiency of transport vehicles. This test was performed from the measurement of fuel consumption, performed by the technical team of CTM/UFMG experimentally and under controlled conditions at the *International Autodrome of Paraíba* located in the municipality of *São Miguel do Taipú*. The tests were performed using nationally manufactured buses and trucks of different models/manufacturers powered by diesel. These vehicles were tested in simulated conditions of urban traffic and road conditions in order to determine, in a comparative manner, the influence of adopting the Green Plus catalyst in fuel consumption and, consequently, in the energy efficiency of these vehicles. The data presented here reflect the comparative behavior of the vehicle under equal conditions operating with regular S10 diesel fuel and with this fuel with the addition of the Green Plus catalyst, under the conditions tested and presented in this report.

## 2 - METHODOLOGY

The methodology used in the test described in this report was divided into 4 steps for better understanding and described below. For such, a qualified technical team linked to the Mobility Technology Center - CTM/UFMG was made available, being the measurement and analysis of the consumption data performed by the technical team of CTM/UFMG.

### 2.1. DEFINITION OF THE OBJECT OF EVIDENCE:

The test objects used in this study were 05 heavy vehicles manufactured in Brazil, whose brands and models were chosen taking into account the diversification of brands and models so that the tests comprised the range of transport vehicles used for transportation of people and cargo. The chosen vehicles are presented in Table 1.

Table 1. Detail of the objects of evidence.

Identification	Brand	Model	Manufacture Year	Model Year	Motorization	Fuel used	Initial mileage [km]
Car #1 Truck	Mercedes	ATEGO 3030 CE	2017	2017	286 hp	Diesel	219.275
Car #2 Truck	Volkswagen	24280 CRM 6x2	2017	2018	277 hp	Diesel	57.267

Car #3 Bus	Scania	Comil Campeone R	2019	2020	310 hp	Diesel	41.521
Car #4 Bus	Volvo	Comil Campeone LD	2013	2014	370 hp	Diesel	499.948
Car #5 Bus	Volvo	Comil Campeone LD	2018	2019	410 hp	Diesel	98.062

Once the choice of models was concluded, the company *Horeb Brasil Energia e Combustíveis Ecológicos Ltda* carried out the selection of the vehicles and also formally hired the drivers, who underwent an introductory training on the project, presented and made their vehicles available for a preliminary technical inspection.

During this inspection the main subsystems of each vehicle were checked, in particular, tyres (make/model/wear), brake system (level of wear), cooling system (general condition), clutch system (level of wear) and exhaust system (general appearance and tightness).

The referred vehicles were inspected as to the condition of the tires and main revision items such as the period of change of the engine lubricating oil, engine oil filter, intake air filter, fuel filter, clutch, safety items such as seat belts, condition of the headlights, brake pads. The objective of this inspection was to ensure the safety and conformity of the tests performed by monitoring items that could eventually present problems or reach the end of their useful life before the tests were concluded.

First, all vehicles had their fuel storage systems drained in order to ensure their supply with regular S10 Diesel and were fueled with regular S10 Diesel supplied by the *Distribuidor DISLUB Energia*, headquartered in Recife. The fueling was performed after weighing the fuel and measuring its temperature and density.

Concluded the stage of selection, preparation and supply of vehicles in the *International Autodrome of Paraíba* in the municipality of *São Miguel do Taipú*, the drivers were trained to perform the tests and the conditioning of the Green Plus catalyst on track. On this occasion, the drivers were oriented and introduced to the driving cycle and all the safety rules for driving vehicles on the racetrack. They were also trained and instructed on the use of communication tools and duly identified by "codenames" (war name).



Parallel to this training, the CTM/UFMG Technical Team performed the drainage of the fuel tank of each vehicle, using for such an external pump system. At this moment, the vehicle was positioned in a leveled area and kept in this position during the entire fuel removal.

Once the drainage of the fuel tanks was finished, each of the vehicles was filled using a gravimetric measurement system, developed by the technical team of CTM/UFMG (digital scale, tank and electric transfer pump), in which the mass of fuel inserted in the tank was controlled. It was also measured, for each fuel sample as mentioned above, its density and temperature. In this way, the initial volume of fuel inserted in each vehicle was controlled before the beginning of the tests.

## 2.2. CHARACTERISATION OF THE FLEET:

This stage of tests was performed with the vehicles supplied with the common S10 fuel of the distributor DISLUB Energia, and the results obtained were called "Base Line". The vehicles performed the test on the circuit of that racetrack, in which the technical team of CTM/UFMG demarcated a driving cycle as shown in Figure 1. Figure 1 shows the track layout, demarcating the route traveled during the tests and during the route of catalyst conditioning in S10 Diesel. The track was used counterclockwise as shown in Figure 1, following the increasing order of numbering.



Figure 1: Layout of the track used for measuring consumption and indicating the route.



According to the website of the *International Autodrome of Paraíba* and confirmed by its manager, the distance traveled each lap is, 3.024 km (1879 miles) and its location is 41 km from the city of João Pessoa, the capital of the state of Paraíba. Aiming to simulate a mixed traffic condition (urban-road), the average time of each lap was controlled by the technical team of CTM/UFMG between 3 minutes and 35 seconds and 3 minutes and 40 seconds.

Under these conditions, the 5 vehicles covered a distance of at least 700 km, spread over 3 consecutive days of testing starting on the second day. The first was dedicated to the installation and assembly of the drainage and fueling structure, tire calibration and adjustment of the racetrack structure for power and operation during the tests. All vehicles were kept full time at the racetrack and circulating only under controlled conditions. At the end of day 3 the trucks were refueled using the gravimetric scale and at the start of day 4 the buses were also refueled. The vehicles were all refueled with a known amount of fuel, keeping the tanks at least 25% of their capacity. The Horeb Brasil team carried out the measurements of pollutant emissions in the exhaust gas system during the 3rd and 4th day of the test.

At the end of the mentioned run (end of the 4th day), the vehicles were again positioned on the same flat and straight pavement and, then, the remaining fuel present in the fuel tank of each one of them was drained, again using the drainage system by external pumps.

The volume of fuel consumed was determined from the difference between the mass of fuel introduced (controlled fill-ups) and removed from the tank at the end of the trip on the racetrack, multiplied by the density of each sample.

### 2.3. CONDITIONING OF THE FLEET:

Once the stage classified as "Base Line" was concluded, the vehicles' conditioning stage was initiated since, according to Horeb Brasil and the tests already conducted with the Green Plus catalyst, a period of continuous use of the fuels aggregated with the Green Plus catalyst is necessary to achieve its highest performance.



In this stage, the vehicles performed the entire fleet conditioning stage inside the race track and following exactly the same route performed during the initial race (baseline), covering 1900 km. For such, Green Plus catalyst supplied by Horeb Brasil was added to the diesel S10 supplied by DISLUB Energia. According to the orientation of the company Horeb Brasil, owner of the Green Plus technology, the Green Plus concentration used in the tests was 50 PPM. The Green Plus catalyst was provided in sufficient quantity to catalyze the fuel used in the tests described in Step 2.4. Following the information contained in the product label, 50 mL were added for each 1,000 liters of fuel.

In the conditioning stage, the vehicles covered a distance of one thousand nine hundred kilometers (1,900 km) on the route established at the racetrack, using S10 diesel aggregated with Green Plus catalyst, during five days of uninterrupted work. To cover the distance foreseen in the conditioning stage, the vehicles used the circuit of the race track, running under the same conditions and at the speeds established for the performance of the tests so as not to allow early wear of tires, and were fueled exclusively on the premises of the race track by the technical team of the CTM/UFMG.

At each refueling, the total distance traveled by each vehicle and volume of fuel supplied at each refueling and the volumetric consumption of the on-board vehicle system were controlled to monitor the catalysis process. The control of the conditioning stage inside the race track had as main objective to avoid irregular and uncontrolled wear of items that affect both fuel consumption and the wear of safety items such as brakes.

#### 2.4. CHARACTERIZATION OF THE FLEET WITH GREEN PLUS:

Once the fleet conditioning stage was concluded, the fuel consumption test stage began at the race track with fuel catalyzed with Green Plus. The drivers went through training again for this test and were reintroduced to the driving cycle and to all the safety rules for driving the vehicles during the test. This driving cycle was the same used in Stage 2.2 (Figure 1), in order to repeat the conditions and allow the comparative analysis of the influence of the Green Plus catalyst on the vehicles' fuel consumption.

In parallel to the training, the CTM/UFMG Technical Team performed again the fuel drainage, using for such the drainage system by external pump already



mentioned in the baseline step, keeping vehicles on a level area throughout the fuel removal.

Once the drainage was finished, the vehicles were again refueled with the fuels added to the Green Plus catalyst, using the same gravimetric measurement system developed by the CTM/UFMG technical team. Each fueled vehicle was then released to the track after checking its partial and total odometer, as well as passing the driving guidelines on the track.

As in Stage 2.2, the vehicles were kept on the racetrack during all test days and driven to the pits, in a staggered manner, at previously established times so that the vehicle could be inspected exactly as the one performed at the base line, through the measurement of pollutant emissions by Horeb Brasil's technical team, and so that the driver could have a brief rest and hydration.

The consumption of each vehicle was determined again from the difference between the mass of fuel introduced in the fueling phase and removed from the tank after the end of the circuit route, the volume being determined by the mass and density measured in each sample.

The fuel consumption of each vehicle was then calculated by dividing the distance traveled and the volume of fuel consumed in traveling that distance. These values were expressed in kilometers per liter (km/L) and reported in "Item 3. Results" of this report.

### 3 - RESULTS

The selected vehicles were tested according to the methodology presented. The uncertainty of the fuel consumption measurement comes from the combination of the uncertainties of the total distance travelled measurement, the fuel mass measurement and the fuel density measurement. The combination of these uncertainties resulted in an uncertainty of +/- 1.5% of the fuel consumption value.

Table 2 shows the results obtained with the application of the methodology presented, for each vehicle tested using the original regular S10 diesel and regular S10 diesel with the addition of Green Plus.

Table 2. Results of the on-track fuel consumption tests.

Identification	Brand	Model	Year Fab./ Mo d.	Fuel used	Fuel Consumption [km/L]		
					Original	Green Plus	Difference (%)
Car #1 Truck	Mercedes	ATEGO 3030 CE	2017/20 17	Diesel	4.0	4.3	7.0



Car #3 Truck	Volkswagen	24280 CRM 6x2	2017/20 18	Diesel	4,5	4.8	7.9
Car #4 Bus	Scania	Comil Campeone R	2019/20 20	Diesel	4,3	4.5	3.3
Car #5 Bus	Volvo	Comil Campeone LD	2013/20 14	Diesel	3,5	4.6	25.3
Car #6 Bus	Volvo	Comil Campeone LD	2018/20 19	Diesel	3,2	5.0	35.8

#### 4 - CONCLUDING REMARKS

This test report presents the results of the evaluation of the use of Green Plus catalyst in the fuel consumption of transport vehicles powered by S10 Diesel, meeting at least the requirements of the EURO V pollutant emissions standard, manufactured in Brazil. The tests were performed by the Technical Team of CTM / UFGM as demanded by the company Horeb Brazil through a request for services. This report presents the methodology used and the results obtained during this evaluation. The test objects were selected from a wide variety of engines in order to obtain significant and comprehensive results to represent the national market, these samples took into account modern engines in production for each vehicle model.

The fuel consumption figures for each vehicle were determined after a minimum distance of seven hundred kilometres (700 km) driven under controlled and cyclical conditions, aiming to reduce the seasonal influences found on public roads. The uncertainty associated with consumption values is  $\pm 1.5\%$ , whose main source of error is in the measurement of the total distance traveled by the vehicles. During the performance of the tests over a total of 3300 km no vehicle presented any defect or malfunction, either in the fuel injection system or in the safety systems of the vehicles.

