CTM-UFMG
CENTRO DE TECNOLOGIA DA MOBILIDADE

TEST REPORT

DETERMINATION OF THE INFLUENCE OF THE GREEN PLUS CATALYST ON THE ENERGY EFFICIENCY OF PASSENGER CARS

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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 passenger cars. This test was performed from the measurement of fuel consumption, performed by the technical team of CTM/UFMG experimentally and under controlled conditions (Autodrome) using national vehicles of different models/manufacturers and equipped with multi-fuel technology (Flex). Such vehicles were tested under simulated urban traffic conditions aiming to determine, in a comparative manner, the influence of adopting the Green Plus catalyst on fuel consumption and, consequently, on the energy efficiency of these vehicles. The data presented here reflects the behavior of the vehicle using after engine modification, 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 objects of proof used in this study were 10 vehicles manufactured in Brazil, whose brands and models were chosen according to the total number of vehicles sold in the country, according to the National Association of Automotive Vehicle Manufacturers - ANFAVEA, opting for the best-selling models in the compact *hatch* segment. 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	Hyundai	HB20	2019	2019	1.0 12V Flex	Ethanol	62.692
Car #2	Hyundai	HB20	2013	2014	1.0 12V Flex	Gasoline	102.315
Car #3	Ford	Ka	2018	2018	1.0 12V Flex	Gasoline	100.180
Car #4	Ford	Ka	2018	2018	1.0 12V Flex	Ethanol	42.100
Car #5	Fiat	Argo	2020	2020	1.0 6V Flex	Gasoline	16.012
Car #6	Fiat	Argo	2019	2019	1.0 6V Flex	Ethanol	50.089
Car #7	Renault	Sandero	2014	2014	1.0 16V Flex	Gasoline	60.200
Car #8	Renault	Sandero	2015	2016	1.0 16V Flex	Ethanol	68.733
Car #9	Chevrolet	Onix	2019	2019	1.0 8V Flex	Ethanol	46.300
Car #10	Chevrolet	Onix	2017	2018	1.0 8V Flex	Gasoline	53.078

Once the choice of models was concluded, the technical team of the CTM/UFMG carried out the selection of the vehicles and 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 (brand/model/wear), brake system (level of wear), cooling system (general condition), clutch system (level of wear) and exhaust system (general appearance and tightness).

These vehicles also underwent a review of items associated with the engine, and those that were due during the test period were replaced, such as engine lubricant oil, engine oil filter, intake air filter, fuel filter, spark plugs, or those that could eventually present problems or reach the end of their useful life before the completion of the tests, such as brake pads, tires, clutch.

These vehicles were divided into two groups, in which 5 vehicles were supplied with regular gasoline and the other 5 with hydrated ethanol, both fuels supplied by ALESAT. The first fueling of each vehicle was performed with a sample of the fuel acquired for the tests, whose objective was the setting of the tank and auto adjustment of the multi-fuel system. Each vehicle circulated on public roads for more than one day and consumed at least 30 liters of fuel.

Once the vehicle selection, preparation, and environment stage was concluded, the vehicles were directed to the MegaSpace racetrack in Santa Luzia/MG, where the drivers underwent specific training, at which time they were oriented and introduced to the driving cycle and all the safety rules for driving the vehicles on the racetrack. They were also trained and instructed on the use of communication instruments and duly identified by numbers, according to Table 1.

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

Once the fuel tanks were drained, each vehicle was filled using a gravimetric measurement system, developed by the technical team of CTM/UFMG (digital scale, reservoir and electric transfer pump), in which

controlled the mass of fuel inserted into the tank. It was also measured, for each fuel sample, 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 original fuel, and the results obtained were called "Base Line". The vehicles were directed to the MegaSpace racetrack, in which the CTM/UFMG technical team demarcated a driving cycle with fixed gear shift indications and a mandatory stop point. Figure 1 presents an aerial view of the track, along with the indication of the gear shift points, signaled by the number and position of cones distributed along the circuit (indication of the gear to be used). The track was used in counterclockwise direction (indicative arrows), with the beginning indicated in Figure 1.

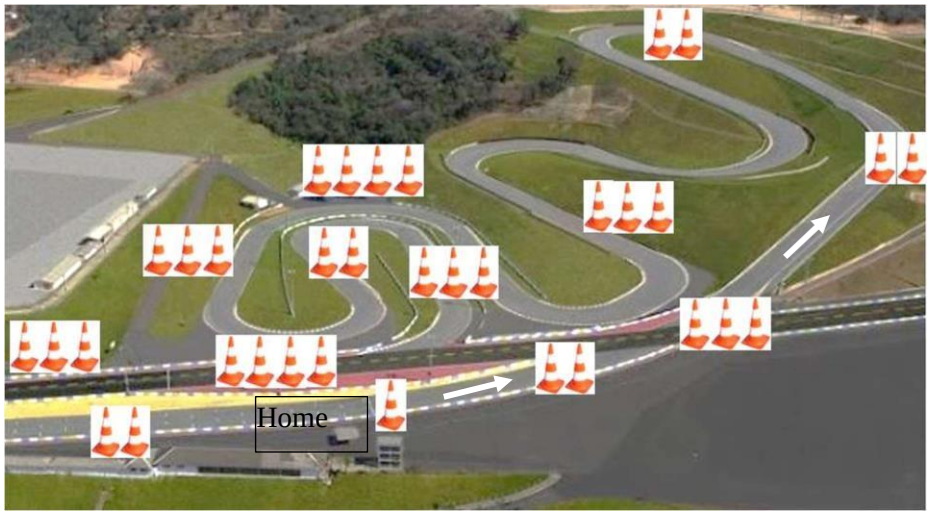

Figure 1: Aerial view of the track used for measuring consumption and indication of the exchange points and inserted gear (cones).

According to the person in charge of Autódromo MegaSpace, the distance covered on each lap is approximately 2,600 meters (2.6 km). In order to simulate an urban traffic condition, the average time of each lap was controlled by the technical team of CTM/UFMG between 200 and 220 seconds and a mandatory stop was inserted in each lap.

Under these conditions, the 10 vehicles traveled a distance of over 700 km, distributed over 3 consecutive days of testing, in which they were kept full time at the race track and circulating only under controlled conditions. At the end of the 1st and 2nd days, the vehicles were refueled with a known amount of fuel, keeping the tanks at least 25% of their capacity.

At the end of the mentioned run (end of the 3rd day), the vehicles were again positioned on the same flat and straight pavement and, in the sequence, the remaining fuel present in the fuel tank of each one of them was drained, using again the original system of fishing and sending fuel (electric fuel pump).

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 from 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 two groups of vehicles were maintained, being the same 5 vehicles supplied with regular gasoline + Green Plus catalyst and the other 5 supplied with hydrated ethanol + Green Plus catalyst, provided by ALESAT (fuels) and by Horeb Brasil (Green Plus). According to Horeb Brasil, the concentration of Green Plus used in the tests was 50 PPM. The Green Plus catalyst was supplied in sufficient quantity to catalyze the fuel used in the tests described in Step 2.4. Following the information contained in the product label, 77 mL were added for each 1,000 liters of fuel.

From the beginning of the conditioning period, the vehicles covered a distance of at least one thousand and seven hundred kilometers (1,700 km) using the fuels aggregated with the Green Plus catalyst, in 10 days of uninterrupted work. To cover the distance foreseen in the conditioning stage, the vehicles used public roads of the Metropolitan Region of Belo Horizonte/MG (RMBH), being fueled exclusively on CTM/UFMG premises by its technical team.

At each fuelling, the total distance traveled by each vehicle and volume of fuel supplied at each fuelling were controlled. This control was carried out exclusively as a tool for monitoring the conditioning process. The monitoring also included the use of satellite trackers, provided by the company ALESAT, for greater control of the conditions of use of the vehicles during the stages.

2.4 . CHARACTERISATION OF THE FLEET WITH GREEN PLUS:

Once the fleet conditioning stage was concluded, the vehicles and respective drivers were again driven to the same circuit used in Stage 2.2. At the race track, the drivers were again trained and reintroduced to the driving cycle and to all safety rules for driving the vehicles. 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 original pumping system of the vehicle, keeping it in a leveled area during the whole 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 race track during all test days and taken to the pits, in a staggered manner, at previously established times for the vehicle to be inspected, through the measurement of pollutant emissions by Horeb Brasil's technical team, and for the driver to take 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 presents the results obtained with the application of the methodology presented, for each vehicle tested using the original fuel and the fuel catalyzed with Green Plus.

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

Identification	Brand	Model	Year of Manufacture/Mod.	Fuel used	Fuel Consumption [km/L]		
					Original	Green Plus	Difference
Car #1	Hyundai	HB20	2019/2019	Ethanol	9,0	9,8	8,8% (1)
Car #2	Hyundai	HB20	2013/2014	Gasoline	12,5	13,1	4,6% (2)(3)
Car #3	Ford	Ka	2018/2018	Gasoline	12,3	13,5	9,5%
Car #4	Ford	Ka	2018/2018	Ethanol	8,4	8,2	- 2,0% (4)
Car #5	Fiat	Argo	2020/2020	Gasoline	11,3	12,8	13,6% (5)
Car #6	Fiat	Argo	2019/2019	Ethanol	8,9	9,9	10,8% (6)
Car #7	Renault	Sandero	2014/2014	Gasoline	10,3	10,9	5,6% (6)
Car #8	Renault	Sandero	2015/2016	Ethanol	8,4	9,3	11,8%
Car #9	Chevrolet	Onix	2019/2019	Ethanol	10,1	10,6	4,9%
Car #10	Chevrolet	Onix	2017/2018	Gasoline	13,5	14,5	7,4% (7)

(1) Vehicle required replacement of brake pads during Stage 2.3. Replacement performed by the CTM/UFMG technical team with a component of the same make/model as the removed one;

(2) Vehicle demanded replacement of the speed sensor during Stage 2.2. Replacement performed by a component of the same measure, brand and model of the removed component.

(3) Total distance travelled determined by the number of laps on the circuit during testing;

(4) Vehicle required replacement of front tires during Stage 2.4. Replacement performed by a component of the same size, but of a different brand and model from the removed component, since tires of the same brand and model were not found on the market;

(5) Vehicle demanded front tires replacement during Stage 2.4. Replacement made with a component of the same size, brand and model of the removed component.

(6) Vehicle demanded front tires replacement during Stage 2.3. Replacement made with a component of the same size, brand and model of the removed component.

(7) Vehicle required replacement of brake pads during Stage 2.2. Replacement performed by the CTM/UFMG technical team with a component of the same make/model as the removed one;

4 - CONCLUDING REMARKS

This test report presents the results of the evaluation of the use of Green Plus catalyst in the fuel consumption of passenger cars with multi-fuel technology and manufactured in Brazil, performed by the CTM/UFMG Technical Team for the company

Horeb Mercosul through a service provision request. In this report is

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presented the methodology used and the results obtained during this evaluation. The objects of proof were selected from a market analysis being, these, samples of the most sold models in Brazil and equipped with the most modern engines in production for each 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 the consumption values is ± 1.5%, whose main source of error is in the measurement of the total distance travelled by the vehicles.

It should be noted that the demand for component replacement during the tests, as described in Table 2, was not foreseen and may promote changes in the test object to the point of influencing the final value of the measured consumption. For this reason, whenever possible, the replacement was performed for similar components (same brand, model, size, application) and following the procedure recommended by the vehicle manufacturer, aiming to minimize the influence of this procedure on the test object. Component exchanges were only performed in cases where the safety of the participants was compromised and the exchange was unavoidable.

In particular, the object of evidence identified as **"Car #4"** presented an accentuated wear of the front tires initially applied, requiring their replacement. As the brand of this component is of low production volume, no tires of the same brand and model were found, keeping only their size and the characteristic of their manufacturing process (*Remold*). This fact is relevant as regards the promotion of changes in the object of evidence and, therefore, the CTM/UFMG Technical Team considered that the value of fuel consumption found is the result of the combination of more than one factor, whose nature was not determined. Thus, the uncertainty associated to this measurement could not be determined and expresses only the result of the factors controlled and monitored during the tests. Thus, the presented measured was considered as not representative among the other values found in the tests performed.