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Emissions and Fuel Consumption comparison of a Toyota Prius Gasoline-Electric Hybrid Vehicle Model year 2001 to an Average Mid-Size Car.

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Executive Summary

The Fleet Management and Emissions Research and Measurement Division (ERMD) of Environment Canada collaborated on a test project to evaluate a Toyota Prius gasoline-electric hybrid vehicle. This experimental vehicle assessment is part of an Environment Canada on going new vehicle technology evaluation program.

The exhaust emissions testing was conducted at Environment Canada's ERMD Laboratory. The testing at the ERMD laboratory showed that on the simulated chassis dynamometer urban driving cycle, the vehicle would get a fuel consumption of 4.19 L/100km or approximately 2.5 times less fuel than an average mid size vehicle. Over the highway driving cycle, it would get 3.81 L/100 km or approximately 1.64 times less fuel than an average mid size vehicle.

In the urban mode, when compared to an average mid size car , the electric-hybrid showed that the emissions of carbon monoxide, oxides of nitrogen and total hydrocarbons were approximately 10 times less, while the carbon dioxide emissions were reduced by half.

In the highway mode, when compared to an average mid size car , the electric-hybrid showed that the emissions of carbon monoxide were approximately 4 times less, oxides of nitrogen were 6 times less, total hydrocarbons were approximately 30 times less, while the carbon dioxide emissions were reduced 1.64 times.

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1.0 Background

Light duty passenger vehicles are significant contributors to the air pollution problem in urban centers and to the global CO2 problem. In it's effort to identify means of transportation that would help to improve air quality, Environment Canada through the Emissions Research and Measurement Division, performs standardized emissions and fuel consumption testing on different types of light duty passenger vehicles. The department, other government departments and the public use this information, when they are purchasing new vehicles.

2.0 Introduction

The test program consisted of an evaluation of the comparative performance of both vehicle types in terms of emissions and fuel consumption resulting from the operation of the vehicles over simulated urban, highway, aggressive and air conditioning driving cycles on a chassis dynamometer, at a temperature of 20C

The following report discusses the procedures that were undertaken at the ERMD laboratory and results of the testing of these two types of vehicles.

3.0 Objective

To measure the exhaust gas emissions and fuel consumption from the gasoline-electric Toyota Prius vehicle for purposes of evaluating it's potential benefit to the environment when compared to a mid size gasoline powered car.

4.0 Overview

The gasoline-electric Toyota Prius vehicle was tested on a chassis dynamometer at Environment Canada's ERMD Laboratory in Ottawa, using the emissions and fuel consumption certification cycles for urban, highway, aggressive and loaded A/C conditions at +20°C. The measurements were then evaluated for emissions and performance benefits when compared to a previously tested gasoline fueled mid size passenger car.

4.1 Test Outline

4.1.1 Vehicle

The test vehicle was a Toyota Prius. KW. The test parameters for the vehicle were: Inertia weight 3500 lbs, RLHP 8.4 at 50 mph.

4.1.2 Fuel

The fuel used for the emissions test was indolene. This fuel is the certified gasoline used for the emissions compliance program for new motor vehicles in Canada and in the U-S

4.1.3 Instrumentation

The instrumentation used for the various test activities was as follows:

•Dynamometer: single roll 24-inch diameter DC electric

•Analysis system used to measure the internal combustion engine exhaust emissions is the same as for the compliance program composed of a Constant Volume Sampler, Non Dispersive Infrared instrument for CO and CO2., a Flame Ionization Detector for the THC, and a Chemiluminescent Analyzer for NOX..

4.2 Methodology

1. Replace the vehicle's fuel with indolene.

2. As the initial step in testing the hybrid vehicle on the dynamometer it was necessary to determine the RLHP of the vehicle. This was required in order to establish the three-point coefficient curve for the dynamometer loading. The process consisted of conducting coast downs on the dynamometer in order to match the on road coast down times supplied by the manufacturer.

3. Test the vehicle as per the urban, highway, aggressive and air conditioning dynamometer driving cycles.

5.0 Results and Discussion

The following tables summarize the test data obtained during the testing of the Prius.

TABLE 1

TOYOTA PRIUS
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URBAN DYNAMOMETER DRIVING CYCLE (UDDS)

Date	CO g/m	CO2 g/m	NOX g/m	THC g/m	CH4 g/m	FE L/100 km
Jan-01	0.120	158.030	0.025	0.010		4.190

HIGHWAY TEST CYCLE (HWFCT)

Date	CO g/m	CO2 g/m	NOX g/m	THC g/m	CH4 g/m	FE L/100 km
Jan-01	0.045	143.420	0.010	0.001		3.805

AGRESSIVE CITY DRIVING (US06)

Date	CO g/m	CO2 g/m	NOX g/m	THC g/m	CH4 g/m	FE L/100 km
Jan-01	0.03	189.21	0.015	0.001		5.015

AIR CONDITIONING TEST CYCLE (SC03)

Date	CO g/m	CO2 g/m	NOX g/m	THC g/m	CH4 g/m	FE L/100 km
Jan-01	0.105	176.54	0.015	0.0005		4.685

Table 2 Generic mid size car emissions

URBAN DYNAMOMETER DRIVING CYCLE (UDDS)						
Date	CO g/m	CO2 g/m	NOX g/m	THC g/m	CH4 g/m	FE L/100 km
	1.050	408.500	0.250	0.180		10.820
HIGHWAY TEST CYCLE (HWFCT)						
Date	CO g/m	CO2 g/m	NOX g/m	THC g/m	CH4 g/m	FE L/100 km
	0.180	235.240	0.060	0.030		6.250

The gasoline-electric hybrid vehicle test results are described in table 1. These values are used to do a comparison to emissions and fuel consumption of an average mid size vehicle. The data in table 2 reflects values of vehicles previously tested. For purposes of comparing the emission levels from a hydbrid system to the maximum allowable limits for new gasoline powered vehicles, the new vehicle exhaust emissions standards are provided in Tables 3 and 4.

Table 3. Emissions standards

TIER 1 Standards

Model year 2001-2003

80,000 km	CO (g/mile)	NOx (g/mile)	NMHC (g/mile)	THC (g/mile)	EVAP (g/test)	diesel PM (g/mile)
Light Duty Vehicle (LDV&LDT) on gas or methanol	3.40	0.40	0.25	0.41	2.0/2.5**	0.08

Table 4 Emissions standards

LEV Emission Class
Model year 2001-2006

80,000 km	CO (g/mile)	NOx (g/mile)	NMOG (g/mile)	HCHO (g/mile)	EVAP (g/test)	diesel PM (g/mile)
Light Duty Vehicle (LDV), LLDT	3.40	0.20	0.075	0.015	2.0/2.5**	-

Table 5 Ultra low vehicle emission standards

ULEV Emission Class
Model year 2001-2006

80,000 km	CO (g/mile)	NOx (g/mile)	NMOG (g/mile)	HCHO (g/mile)	EVAP (g/test)	diesel PM (g/mile)
Light Duty Vehicle (LDV), LLDT	1.7	0.20	0.040	0.015	2.0/2.5**	-

Table 3 contains the Tier 1 vehicle emissions standards. Table 4 contains the Low Emission vehicle standards and Table 5 contains the ultra low emission vehicle standards.

For each segment of 10,000km of urban driving, it has been calculated from the Prius data that the total CO production is reduced by 5.78 kg, CO2 by 1,556.68 kg, NOx by 1.4, THC by 1.06 and fuel consumption is reduced by 663 liters. Table 6 summarizes this information.

Table 6

Comparative table Kg of pollutants produced and litres of fuel consumed per 10,000 km of urban driving

	CO Kg / 10k km	CO2 Kg / 10k km	NOX Kg / 10k km	THC Kg / 10k km	CH4	FE L / 10k km
Prius	0.75	982.16	0.16	0.06		419.00
Mid size	6.53	2538.84	1.55	1.12		1082.00
Reduction with Prius	5.78	1556.68	1.40	1.06		663.00

Table 7 shows that for each segment of 10,000 km of highway driving, the total CO production is reduced by 0.84 kg, CO2 by 570.67 kg, NOx by 0.31, THC by 0.18 and fuel consumption is reduced by 244 liters.

Table 7

Comparative table Kg of pollutants produced and liters of fuel consumed per 10,000 km of highway driving

	CO Kg / 10k km	CO2 Kg / 10k km	NOX Kg / 10k km	THC Kg / 10k km	CH4	FE L / 10k km
Prius	0.28	891.36	0.06	0.01		380.50
Mid size	1.12	1462.03	0.37	0.19		625.00
Reduction with Prius	0.84	570.67	0.31	0.18		244.50

In this report, only the urban and highway emission were compared, the US06 and SC03 test data are included as reference only.

6.0 Conclusion

From this test program, it can be seen that the use of this particular gasoline-hybrid vehicle has the potential to provide significant benefits to the environment, especially in the urban area where transportation is a major contributor to the pollution burden.