Traffic & Transport
Anna van Buerenplein 1
2595 DA Den Haag
P.O. Box 96800
2509 JE The Hague
The Netherlands

www.tno.nl

T +31 88 866 00 00

TNO report

TNO 2019 R11250

High emission vehicles in Toyota campaign

Date	28 October 2019
Author(s)	Quinn Vroom, Norbert Ligterink
Copy no	2019-STL-REP-100324161
Number of pages	11 (incl. appendices)
Sponsor	Louwman & Parqui
Project name	Vuilste auto campagne
Project number	060.40338

Summary

On May18th, 2019 Toyota organized a contest called ‘We Want Your Diesel’.
In the context of that campaign, the task of TNO was to find the most polluting vehicle among the vehicles of the contestants. . For the campaign ten candidate vehicle owners were invited and their vehicles were measured in a one-day campaign. The exhaust gas was tested for NO_x concentration and particle matter. The vehicle with the highest polluter score, a 1985 VW Golf GTD, was deemed the most polluting vehicle among the contestants.

Contents

1 Introduction

On May 18th, 2019 Toyota organized a contest called ‘We Want Your Diesel’. The goal was to find the most polluting passenger vehicle in the Netherlands, crush it and replace it by a new Toyota Corolla Hybrid. For the campaign ten candidate vehicles were selected from a database of licence plates delivered by Toyota. These ten vehicles’ owners were invited and their vehicles were measured, in an idle test and a higher engine speed idle test. The exhaust gas was tested for NO_x concentration and particle matter (particle number and opacity measurements). The values acquired by the measurement were compared to a reference based on average Euro-1 vehicle emissions. Using this a scrapping score was given. The vehicle with the highest score, a 1985 VW Golf GTD, was deemed the most polluting and therefore crushed.

Apart from these two tests per vehicle for the rating, also a Periodic Technical Inspection (Dutch: APK) free acceleration test was carried out on the diesel vehicles. Not all vehicles would have passed the periodic inspection. Some vehicles were not roadworthy in that respect. Since this was not stipulated in the competition conditions by Toyota, it was not a reason to exclude these vehicles from the competition.

This type of ‘parking lot measurements’ are planned in the H2020 uCARe project (https://www.project-ucare.eu/) and this contest was a good experience for the uCARe parking lot awareness raising pilots. uCARe therefore received permission from Louwman & Parqui to publish the approach and results of the contest within the project.

DISCLAIMER
This report only contains vehicle make, model and year of production to identify the ten participating vehicles. The vehicles concerned were old, therefore maintenance and deterioration beyond the legal requirements may have played an important role in the measured emission levels. To respect privacy of the owners, there are no license plate numbers of the participating vehicles.

2 Vehicle Selection

Toyota supplied over 700 possible candidate vehicles for the campaign, who entered the competition. In some cases invalid information, e.g., non-existent license plate numbers, was entered. These data were discarded. The information contained license plate and odometer reading of each vehicle. These vehicles were divided over five different classes.

The vehicle classes selected, from which vehicles were pooled, were those with known high average emissions according to the Dutch emission inventory.[1] The average emissions of these vehicles are typical a factor ten or more higher than the average emission of a Dutch passenger car, on particulate matter or NO_x or both.

Table 1: Supplied vehicles, in classes

Class	Description	Amount
A	Diesel 1987-1992	4
B	Diesel pre-1987	11
C	Diesel direct injection Euro-2 or Euro-3	269
E	Gasoline pre-1987 (without catalytic converter)	2
X	Not eligible	485
	Total	771

From the vehicles in class “A” until “E”, ten potential candidates and ten backup candidates were selected. The selection process was done by starting at the first class (A), selecting the vehicle with the highest odometer reading and moving to the next class. This was done for class A until E and repeated until a list of 10 vehicles was acquired.

There were also some additional requirements:

- selecting at least 4 different makes,
- selecting the same make twice in one class was not allowed, and
- selecting the same vehicle model twice was not allowed in the whole list.

This process was repeated a second time to build the backup list. From the 20 potential candidates, 10 were invited to the event. Due to an uneven spread not every category was represented equally. Candidates were invited by Toyota to bring their car, some have declined the invitation.

This led to the following vehicles being measured as shown in Table 1.

[1] www.emissieregistratie.nl

Table 2: Specifications of the tested vehicles

Make	Model	Production year	Engine	Fuel	Category	Odometer
Mercedes	300E AUT	1986	3.0, 6cyl	Diesel	b	536527
Ford	Galaxy TDI	2004	1.9, 4cyl	Diesel	c	588138
Jaguar	X-Type	2003	2.0, 4cyl	Diesel	c	657156
Volvo	V70	1999	2.5, 5cyl	Diesel	c	596461
Audi	A4	2000	2.5, 6cyl	Diesel	c	371139
Mercedes	C200 CDI	2002	2.1, 4cyl	Diesel	c	627091
Saab	900i	1984	2.0, 4cyl	Gasoline	e	330561
Volkswagen	Golf GTD	1985	1.6, 4cyl	Diesel	b	321364
Citroen	CX25 turbo	1987	2.5, 4cyl	Diesel	a	257821
BMW	325d	1998	2.5, 6cyl	Diesel	c	640208

3 Measurement setup

The exhaust gas of every vehicle was tested for NO_x and particle matter.
The measurement was performed using a warmed-up engine. First, the exhaust gases were tested during idling, subsequently, it was tested on a fixed increased engine speed (RPM) of around 2500 min^{-1}. For both tests the measurement was started once the vehicle emissions were stable. The following equipment was used:
a portable Smart Emission Measuring System (SEMS) for measuring NO_x,
a TSI-NPET for measuring particle number (PN), a smoke opacity meter.
A 4-gas analyser was used to provide context of the results for gasoline cars, for example, to compare to PTI lmits.

Table 3: Equipment used for measurements

Equipment	**Used for**
Portable SEMS	NO_x concentration
TSI-NPET	Number of particles
Smoke opacity meter	Visible smoke
4-gas analyser	diagnostic

Figure 1: Overview of the measurement setup

In Figure 1 the measuring station is displayed. On the left is the portable SEMS, with a rubber tube to connect to the exhaust of the vehicles. The NPET is visible on top of the black crate in the middle. The 4-gas analyser is on top of the white desk on the right. The smoke opacity meter is placed behind the NPET and thus not visible in the photo.

4 Results

The vehicles were measured using the setup described in the previous chapter. The sensor data of all the equipment was used to calculate the amount of grams NO_x and amount of particles per kg of CO_2 in the exhaust gas. The outcome was compared to the average values of NO_x and particles of Euro-1 Diesel vehicles, listed under “Reference” in table 4 below.

To each vehicle a scrapping score was given, based on the measurements. The vehicle with the highest score was the most polluting one. The score was calculated using the Root Mean Square (RMS) value of measurements compared to Euro-1 Diesel reference for particulate matter and NO_x from the national inventories.

The scrapping score became:

$$Score = 0.5\sqrt{(\frac{\#PT\_ref}{\#PT\_ref})^2 + (\frac{NOx\_ref}{NOx\_ref})^2 + (\frac{\#PT\_high\_RPM}{\#PT\_high\_RPM})^2 + (\frac{NOx\_high\_RPM}{NOx\_high\_RPM})^2}$$

The measurements delivered the following results.

Table 4: Test results

Make	**Model**	**NO_x Low idle**	**PN Low idle**	**NO_x High idle**	**PN High idle**	**Score relative to Euro-1**
Mercedes	300E AUT	3.5	8.4E+13	2.4	1.1E14	1.424
Ford	Galaxy TDI	7.0	1.4E+14	4.3	5.3E+13	1.710
Jaguar	X-Type	7.3	7.2E+13	6.5	5.3E+13	1.328
Volvo	V70	8.6	1.3E+13	5.4	1.2E+14	1.612
Audi	A4	6.9	8.0E+13	6.4	6.3E+13	1.389
Mercedes	C200 CDI	8.3	1.2E+14	4.8	2.6E+13	1.597
Saab (gasoline)	900i	0.1	3.9E+13	0.0	1.4E+13	0.411
Volkswagen	Golf GTD	5.8	3.3E+14	6.0	2.6E+14	4.289
Citroen	CX25 turbo	2.4	5.9E+13	3.0	3.2E+14	3.228
BMW	325d	4.0	3.5E+13	3.4	6.0E+13	0.876
Reference		5 [gNOx/kgCO_2]	5E+13 [#PN/kgCO_2]	5 [gNOx/kgCO_2]	5E+13 [#PN/kgCO_2]	

5 Conclusion

After the measurements were completed, the combined measurements of particles and NO_x emission resulted in a ‘top 3’ ranking of the dirtiest cars compared to an average Euro-1 Diesel car:

1. VW Golf GTD: 4.3 x higher than Euro-1 diesel average
2. Citroën CX25 turbo: 3.2 x higher than Euro-1 diesel average
3. Ford Galaxy: 1.7 x higher than Euro-1 diesel average

As a result, the Volkswagen Golf GTD was scrapped and the owner was rewarded with a new Toyota Corolla Hybrid.

6 Acknowledgement

This type of ‘parking lot measurements’ are planned in the H2020 uCARe project (https://www.project-ucare.eu/) and this dirtiest car contest was a good experience for the uCARe parking lot awareness raising pilots. uCARe therefore received permission from Louwman & Parqui to publish the approach and results of the contest within the project.

7 Signature

The Hague, 28 October 2019

Paul Tilanus
Projectleader

TNO

Norbert Ligterink
Author