Eco-driving test results

DRAFT v2

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Executive summary

Training a sample of motorists in "eco-driving" techniques delivered improvements in fuel consumption and pollutant emissions in a majority of cases – most strongly with instructor training, and to only a limited extent with an advice leaflet. The average fuel consumption improvement was 6.9% with instructor training and just 1.7% with the leaflet, both compared to the control group baseline. There was a 1.7% reduction in fuel consumption within the control group, which received no training, which may be due to residual variability around ambient conditions or drivers being more familiar with the course.

These gains were mirrored in an average 7.1% reduction in carbon dioxide emissions and 27.3% reduction in carbon monoxide emissions with the instructor training.

The results were more mixed in terms of nitrogen oxide emissions. For the Euro 5 vehicle the average reduction was 27.5% yet for the Euro 6 vehicle there was an average increase of 51.1%. A potential explanation is the interaction between driving style and the active after-treatment system on the Euro 6 vehicle, although the sample size is not large enough to form a strong conclusion.

Objectives

The project was initiated by the Energy Saving Trust (EST) to respond to a specification from Highways England to carry out an "Evaluation of the effectiveness that adopting eco-driving practices could have on air quality alongside the strategic road network (SRN)". This requirement was outlined in the Highways England specification. The objectives were to:

1) Collect baseline emissions data using Portable Emission Monitoring Systems (PEMS) for 18 drivers using a combination of Euro 5 or 6 diesel cars, based on real-world driving on the strategic road network and local roads.

2) Evaluate whether the use of eco-driving techniques, and the approach to the delivery of any training and advice is effective at lowering vehicle emissions, in particular NO_x and NO_2.

3) Collect emissions data for all drivers following the eco-driving training/advice using the same Euro 5 and 6 diesel car and test route.

4) Evaluate the real-world performance of eco-driving techniques on CO_2, CO, NO, NO_2 and NO_x emissions, and fuel usage. The outcome from the testing should be sufficiently statistically robust that it can be relied upon to inform Highways England's future policy development.

The issue of air quality is high on the agenda of the UK Government, and Highways England has an objective to reduce air quality emissions on the Strategic Road Network. One area that lacks empirical evidence is the effect of the driver on NO_x/NO_2 emissions whilst driving on the SRN. EST has conducted a study to assess the impact of NO_x/NO_2 whilst driving on a mixed drive cycle, but this used one single professional driver for consistency.

This study goes further. It is intended to assess whether providing drivers with advice and training on eco-driving techniques can improve the real-world NO_x/NO_2 emissions of diesel cars when driven by "normal" drivers.

Test dates

Testing was conducted between 29 January and 2 March 2018 in and around Stokenchurch, Buckinghamshire, UK on a route devised by EST in consultation with Highways England and Emissions Analytics.

Test equipment and setup

Test equipment was the Sensors SEMTECH-LDV for gaseous emissions. Ambient conditions were measured with a weather station recording temperature, pressure and humidity. The flow tube was mounted on the exterior of the vehicle at the end of the tailpipe, as shown in the photo in Appendix 4.

The SEMTECH-LDV, is Sensors' 5th generation PEMS. The system directly addresses the challenges created by the RDE-LDV standards recently promulgated by the European Union, which require that passenger cars be tested under real world conditions as part of the certification process. Further details can be found at: http://www.sensors-inc.com/.

Equipment calibration

At the start and end of each cycle of tests the gaseous measurement equipment had a span and zero calibration performed, the span against calibration gas bottles of traceable provenance, and the zero on ambient air. Details of the calibrated span values calibrated can be found in Appendix 1.

The equipment also had current certificates of calibration compliance, for the linearity of the analyser and flow tube, from Sensors, Inc.

Vehicles

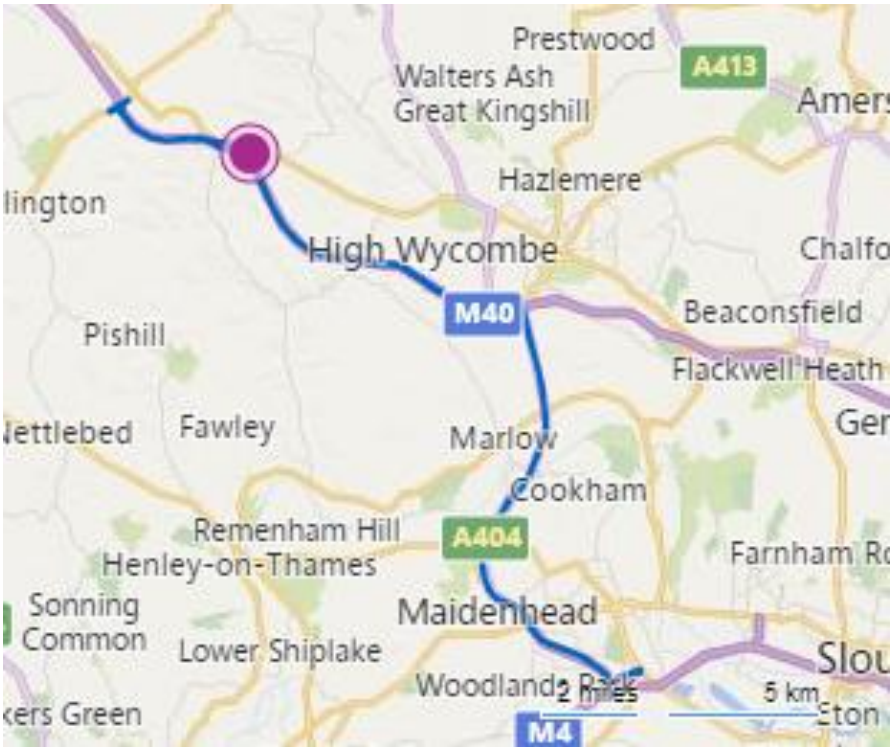
Two generations of the Ford Focus diesel were selected, as high-selling, mid-sized vehicles in the UK market. Both had manual transmissions to allow the driver more control via driving style. The second vehicle had active NO_x after-treatment, and both vehicles had a diesel particulate filter.

Vehicle	Make and Model	VRM	Model Year	Fuel	Engine size (litres)	Trans-mission	Euro stage
Vehicle 1	Ford Focus	KM58 HCU	2008	Diesel	1.6	Manual	5
Vehicle 2	Ford Focus	YR16 XNY	2016	Diesel	1.5	Manual	6

Further details can be found in Appendix 4.

Test cycle

The route map was:

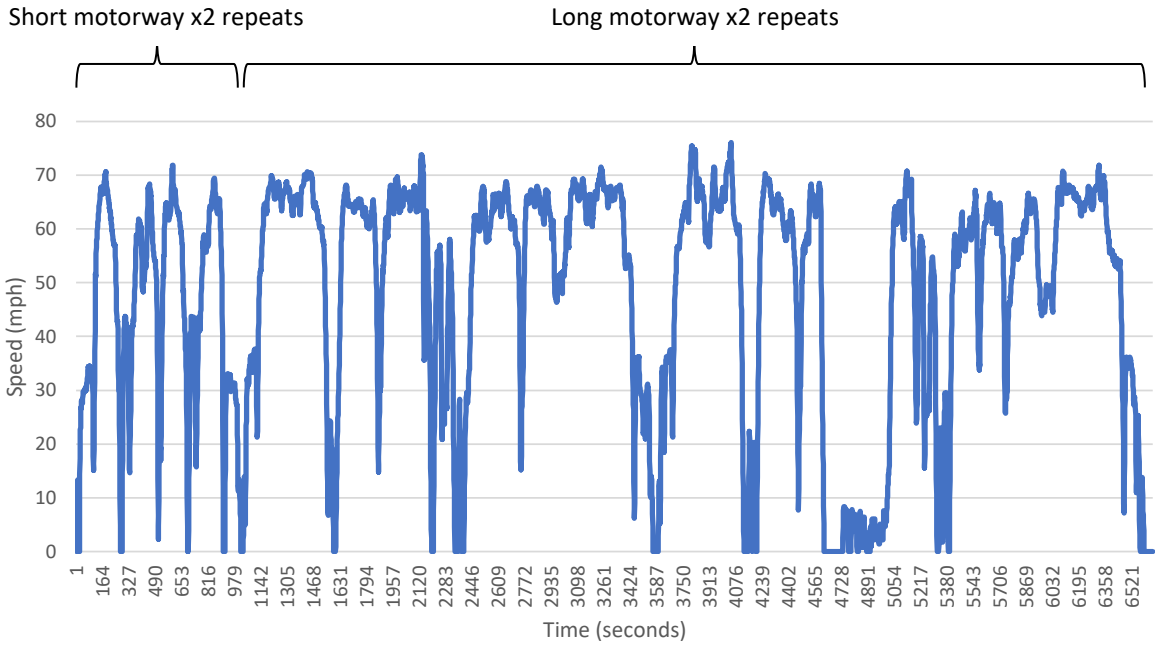


The test cycle consisted of two repeats of a short motorway section followed by two repeats of a long motorway section. The short motorway was primarily one stop northwards on M40 following by a return to the origin. The long motorway followed the M40 south and then the A404 as far as Maidenhead and then a return to the origin.

The dynamic characteristics of the cycles were:

Trip Specifics	Average duration (seconds)	Average distance (miles)	Average speed (mph)
Short motorway	426	5.4	45.9
Long motorway	2486	36.7	53.4

The speed profile of typical test was:

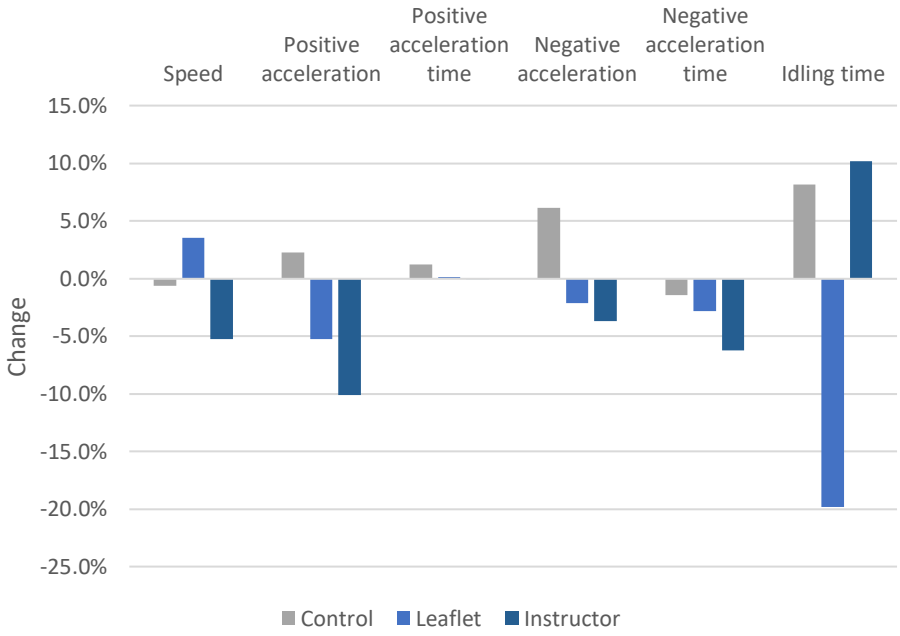


Further details can be found in Appendix 3.

The effect of the interventions had the following average effect on driving dynamics:

Average	Control	Leaflet	Instructor
Short motorway route			
Speed (mph)	-2.5%	2.0%	-1.7%
Positive acceleration (ms^{-2})	1.0%	-5.5%	-21.8%
Positive acceleration time (seconds)	-0.1%	2.4%	5.1%
Negative acceleration (ms^{-2})	4.9%	-4.4%	-16.4%
Negative acceleration time (seconds)	-2.9%	1.6%	-6.7%
Idling proportion (%)	114.0%	107.4%	38.0%
Long motorway route			
Speed (mph)	-0.6%	3.5%	-5.3%
Positive acceleration (ms^{-2})	2.2%	-5.2%	-10.1%
Positive acceleration time (seconds)	1.2%	0.1%	0.0%
Negative acceleration (ms^{-2})	6.1%	-2.1%	-3.7%
Negative acceleration time (seconds)	-1.4%	-2.8%	-6.2%
Idling proportion (%)	8.2%	-19.8%	10.2%

Graphically, the changes on the long motorway route were:



Therefore, the control group tended to drive more aggressively on the second test, but also with more idling. The instructor-trained group demonstrated reduced speeds, acceleration and decelerations. The results from leaflet group typically fell between the control and instructor group.

Test fuel

Standard market diesel fuel (EN590) was used throughout, from the same Shell forecourt in Stokenchurch.

Driver recruitment and training

The drivers were recruited in one of two of ways. First, Highways England recruited drivers from within their pool of employees, mindful of ensuring a representative mix of its Business Driver Network rather than people with a specific interest in sustainability. Second, Emissions Analytics set up a social media group to recruit drivers in the local area. Drivers were paid a £100 gratuity to incentivise compliance with the test requirements.

All tests were conducted under the supervision of an Emissions Analytics' technician in the car.

The drivers were split evenly between the two vehicles and then further divided into three groups, each of which received a different level of training. One third were offered no training, another third was given a leaflet designed by EST and Highways England to read through, and the final third were provided with one hour of training from a qualified Approved Driving Instructor from EST, which covered driving techniques known to improve fuel efficiency.

Analysis

In the design of the test cycle, it was preferred to have fewer repeats of a longer cycle. The results are expressed as the percentage change between the average of the repeats before and after training, split between the short and longer motorway cycles. Due to the small number of repeats, useful tests of statistical significant were not possible.

The effect of DPF regeneration was also considered in the analysis.

Summary results

This table summarises the changes measured by each driver group.

		Fuel consumption	CO_2	CO	NO_x	NO_2
		L/100km	g/km	g/km	g/km	g/km
Control	**Short**	0.7%	0.8%	30.1%	37.2%	7.8%
	Long	-0.7%	-0.6%	28.0%	27.8%	21.6%
	Average	0.0%	0.1%	29.1%	32.5%	14.7%
Leaflet	**Short**	-1.4%	-1.5%	-19.0%	-0.4%	-3.7%
	Long	-1.9%	-2.0%	39.5%	6.4%	0.7%
	Average	-1.7%	-1.7%	10.2%	3.0%	-1.5%
Instructor	**Short**	-9.8%	-9.9%	-4.7%	76.6%	1.7%
	Long	-4.1%	-4.2%	8.3%	12.0%	5.5%
	Average	-6.9%	-7.1%	1.8%	44.3%	3.6%
Leaflet	**Short**	-2.1%	-2.3%	-49.1%	-37.6%	-11.5%
vs Control	**Long**	-1.3%	-1.4%	11.5%	-21.4%	-20.9%
	Average	-1.7%	-1.8%	-18.8%	-29.5%	-16.2%
Instructor	**Short**	-10.4%	-10.7%	-34.9%	39.4%	-6.1%
vs Control	**Long**	-3.4%	-3.6%	-19.7%	-15.8%	-16.1%
	Average	-6.9%	-7.1%	-27.3%	11.8%	-11.1%
Leaflet	**Short**	-8.4%	-8.4%	14.3%	77.0%	5.4%
vs Instructor	**Long**	-2.2%	-2.2%	-31.2%	5.6%	4.9%
	Average	-5.3%	-5.3%	-8.5%	41.3%	5.1%

Diesel particulate filter regeneration

Both vehicles were equipped with diesel particulate filters, which were subject to periodic regeneration. During this period, fuel consumption increases, CO_2 emissions increase and typically NO_x emissions increase.

In this test project, there were two significant features. First, the frequency of regeneration for these cars was high relative to Emissions Analytics' general experience. Second, the modified driving styles post-training led on average to fewer regenerations. Consequently, rather than excluding cycle repeats affected by regeneration – which is the typical methodology – in this case it is important to consider regeneration as an endogenous factor in the results analysis.

The incidence of regeneration was as follows.

	Frequency
Total number of regenerations	29
Regenerations in before-training tests	18
Regenerations in after-training tests	11
Drivers with fewer regenerations after training	8
Drivers with same regenerations after training	7
Drivers with more regenerations after training	3

Therefore, was a lower tendency for regenerations to occur after training.

The table below shows the summary results if cycle repeats with DPF regeneration are excluded.

		Fuel consumption	CO_2	CO	NO_x	NO_2
		L/100km	g/km	g/km	g/km	g/km
Control	**Short**	-0.2%	-0.1%	21.8%	29.5%	5.1%
	Long	1.1%	1.2%	27.1%	20.2%	23.3%
	Average	0.5%	0.5%	24.5%	24.9%	14.2%
Leaflet	**Short**	-2.3%	-2.3%	-11.7%	4.6%	0.8%
	Long	-0.6%	-0.5%	-20.1%	2.5%	-1.5%
	Average	-1.4%	-1.4%	-15.9%	3.5%	-0.3%
Instructor	**Short**	-10.4%	-10.5%	2.7%	56.7%	-7.3%
	Long	-2.3%	-2.4%	-11.5%	23.1%	18.0%
	Average	-6.3%	-6.4%	-4.4%	39.9%	5.3%
Leaflet	**Short**	-2.1%	-2.2%	-33.6%	-24.9%	-4.3%
vs Control	**Long**	-1.7%	-1.7%	-47.1%	-17.8%	-24.7%
	Average	-1.9%	-1.9%	-40.4%	-21.3%	-14.5%
Instructor	**Short**	-10.2%	-10.4%	-19.2%	27.2%	-12.4%
vs Control	**Long**	-3.4%	-3.6%	-38.6%	2.8%	-5.3%
	Average	-6.8%	-7.0%	-28.9%	15.0%	-8.9%
Leaflet	**Short**	-8.1%	-8.2%	14.4%	52.2%	-8.1%
vs Instructor	**Long**	-1.7%	-1.9%	8.5%	20.6%	19.4%
	Average	-4.9%	-5.0%	11.5%	36.4%	5.7%

The conclusion is that the effect of regenerations does increase the fuel consumption gain from eco-driving instructor training, buy only marginally. Including regenerations, the average gain following instructor training was 6.9%, while excluding regenerations the increase was 6.8%. With leaflet training, the fuel consumption gain was 1.7% fuel consumption gain with regenerations and 1.9% gain excluding regenerations.

The remaining results in this report retain regenerations in the analysis.

Euro stage analysis

Segmenting the data between the two different vehicles, the following results are obtained.

		Fuel consumption	CO_2	CO	NO_x	NO_2
		L/100km	g/km	g/km	g/km	g/km
Control	**Euro 5**	5.4%	5.6%	-0.7%	9.8%	8.2%
	Euro 6	-5.4%	-5.4%	58.8%	55.2%	21.2%
	Average	0.0%	0.1%	29.1%	32.5%	14.7%
Leaflet	**Euro 5**	-1.4%	-1.5%	44.9%	8.2%	1.4%
	Euro 6	-1.9%	-2.0%	-24.5%	-2.2%	-4.4%
	Average	-1.7%	-1.7%	10.2%	3.0%	-1.5%
Instructor	**Euro 5**	-2.8%	-2.8%	-1.2%	-17.6%	-7.6%
	Euro 6	-11.0%	-11.3%	4.8%	106.3%	14.9%
	Average	-6.9%	-7.1%	1.8%	44.3%	3.6%
Leaflet	**Euro 5**	-6.8%	-7.1%	45.6%	-1.6%	-6.8%
vs Control	**Euro 6**	3.5%	3.5%	-83.3%	-57.4%	-25.6%
	Average	-1.7%	-1.8%	-18.8%	-29.5%	-16.2%
Instructor	**Euro 5**	-8.3%	-8.4%	-0.6%	-27.5%	-15.8%
vs Control	**Euro 6**	-5.6%	-5.8%	-54.0%	51.1%	-6.3%
	Average	-6.9%	-7.1%	-27.3%	11.8%	-11.1%
Leaflet	**Euro 5**	-1.4%	-1.3%	-46.2%	-25.8%	-9.0%
vs Instructor	**Euro 6**	-9.1%	-9.3%	29.2%	108.5%	19.3%
	Average	-5.3%	-5.3%	-8.5%	41.3%	5.1%

Comparing performance to the regulated standards for NO_x, it is possible to show the degree to which driving training can reduce excess emissions in real-world driving. The table below shows the "exceedance factor", or the ratio between the real-world emissions and the regulated limit.

Average of routes	Before intervention	After intervention	Variance
Vehicle 1 (Euro 5)	4.9	4.9	0.0
Vehicle 2 (Euro 6)	10.3	9.7	(0.6)

The reason for the increase in NO_x emissions for the Euro 6 vehicle after instructor training may be down to an interaction with the active after-treatment system. The lean NO_x trap on this Euro 6 vehicle absorbs NO_x in certain driving condition in fuel-lean driving and then purges the trap in fuel-rich bursts. The degree of absorption and frequency of purging may be affected by driving style, and hence the results emissions.

Detailed results – Fuel economy and consumption

Driver	Vehicle	Group	Route	Test	Fuel Economy	Fuel Consumption
					MPG (UK)	L/100km
Driver 1	2	Instructor	Short	Before	56.7	5.0
Driver 1	2	Instructor	Short	After	61.2	4.6
Driver 1	2	Instructor	Long	Before	65.2	4.3
Driver 1	2	Instructor	Long	After	65.1	4.4
Driver 2	1	Instructor	Short	Before	52.0	5.4
Driver 2	1	Instructor	Short	After	49.3	5.7
Driver 2	1	Instructor	Long	Before	54.3	5.2
Driver 2	1	Instructor	Long	After	54.7	5.2
Driver 3	1	Control	Short	Before	52.7	5.4
Driver 3	1	Control	Short	After	43.7	6.5
Driver 3	1	Control	Long	Before	53.0	5.3
Driver 3	1	Control	Long	After	53.3	5.3
Driver 4	1	Leaflet	Short	Before	48.9	5.8
Driver 4	1	Leaflet	Short	After	45.2	6.3
Driver 4	1	Leaflet	Long	Before	51.3	5.5
Driver 4	1	Leaflet	Long	After	50.2	5.6
Driver 5	1	Instructor	Short	Before	47.9	5.9
Driver 5	1	Instructor	Short	After	51.8	5.5
Driver 5	1	Instructor	Long	Before	52.3	5.4
Driver 5	1	Instructor	Long	After	56.4	5.0
Driver 6	1	Control	Short	Before	53.2	5.3
Driver 6	1	Control	Short	After	48.8	5.8
Driver 6	1	Control	Long	Before	59.0	4.8
Driver 6	1	Control	Long	After	52.3	5.4
Driver 7	1	Control	Short	Before	47.8	5.9
Driver 7	1	Control	Short	After	49.5	5.7
Driver 7	1	Control	Long	Before	50.3	5.6
Driver 7	1	Control	Long	After	54.1	5.2
Driver 8	1	Leaflet	Short	Before	44.2	6.4
Driver 8	1	Leaflet	Short	After	48.8	5.8
Driver 8	1	Leaflet	Long	Before	53.9	5.3
Driver 8	1	Leaflet	Long	After	55.8	5.1
Driver 9	1	Instructor	Short	Before	52.8	5.3
Driver 9	1	Instructor	Short	After	54.9	5.2
Driver 9	1	Instructor	Long	Before	57.1	5.0

Driver 9	1	Instructor	Long	After	59.2	4.8
Driver 10	1	Leaflet	Short	Before	50.3	5.6
Driver 10	1	Leaflet	Short	After	51.9	5.4
Driver 10	1	Leaflet	Long	Before	53.8	5.3
Driver 10	1	Leaflet	Long	After	54.9	5.1
Driver 11	2	Control	Short	Before	52.9	5.3
Driver 11	2	Control	Short	After	54.2	5.2
Driver 11	2	Control	Long	Before	57.6	4.9
Driver 11	2	Control	Long	After	64.0	4.4
Driver 12	2	Control	Short	Before	53.5	5.3
Driver 12	2	Control	Short	After	52.6	5.4
Driver 12	2	Control	Long	Before	58.6	4.8
Driver 12	2	Control	Long	After	58.3	4.8
Driver 13	2	Leaflet	Short	Before	46.1	6.2
Driver 13	2	Leaflet	Short	After	45.9	6.3
Driver 13	2	Leaflet	Long	Before	55.3	5.1
Driver 13	2	Leaflet	Long	After	57.4	4.9
Driver 14	2	Leaflet	Short	Before	55.5	5.1
Driver 14	2	Leaflet	Short	After	59.4	4.8
Driver 14	2	Leaflet	Long	Before	64.1	4.4
Driver 14	2	Leaflet	Long	After	63.2	4.5
Driver 15	2	Instructor	Short	Before	47.7	5.9
Driver 15	2	Instructor	Short	After	57.1	5.0
Driver 15	2	Instructor	Long	Before	62.7	4.5
Driver 15	2	Instructor	Long	After	62.4	4.5
Driver 16	2	Control	Short	Before	42.5	6.7
Driver 16	2	Control	Short	After	54.7	5.2
Driver 16	2	Control	Long	Before	55.6	5.1
Driver 16	2	Control	Long	After	55.2	5.1
Driver 17	2	Instructor	Short	Before	38.2	7.4
Driver 17	2	Instructor	Short	After	54.3	5.2
Driver 17	2	Instructor	Long	Before	51.2	5.5
Driver 17	2	Instructor	Long	After	59.1	4.8
Driver 18	2	Instructor	Short	Before	59.7	4.7
Driver 18	2	Instructor	Short	After	59.3	4.8
Driver 18	2	Instructor	Long	Before	65.3	4.3
Driver 18	2	Instructor	Long	After	69.1	4.1

The table below summarises the variances between the groups.

Driver	Vehicle	Group	Route	Test	Fuel Economy	Fuel Consumption
					MPG (UK)	L/100km
Driver 1	2	Instructor	Short	Variance	7.8%	-7.2%
Driver 1	2	Instructor	Long	Variance	-0.2%	0.5%
Driver 1	2	Instructor	Average	Variance	3.8%	-3.3%
Driver 2	1	Instructor	Short	Variance	-5.3%	5.8%
Driver 2	1	Instructor	Long	Variance	0.8%	-0.9%
Driver 2	1	Instructor	Average	Variance	-2.3%	2.5%
Driver 3	1	Control	Short	Variance	-17.0%	21.4%
Driver 3	1	Control	Long	Variance	0.7%	-0.5%
Driver 3	1	Control	Average	Variance	-8.2%	10.5%
Driver 4	1	Leaflet	Short	Variance	-7.5%	8.1%
Driver 4	1	Leaflet	Long	Variance	-2.1%	2.2%
Driver 4	1	Leaflet	Average	Variance	-4.8%	5.2%
Driver 5	1	Instructor	Short	Variance	8.0%	-7.5%
Driver 5	1	Instructor	Long	Variance	7.8%	-7.2%
Driver 5	1	Instructor	Average	Variance	7.9%	-7.4%
Driver 6	1	Control	Short	Variance	-8.3%	9.1%
Driver 6	1	Control	Long	Variance	-11.5%	12.8%
Driver 6	1	Control	Average	Variance	-9.9%	10.9%
Driver 7	1	Control	Short	Variance	3.4%	-3.1%
Driver 7	1	Control	Long	Variance	7.7%	-7.1%
Driver 7	1	Control	Average	Variance	5.6%	-5.1%
Driver 8	1	Leaflet	Short	Variance	10.4%	-9.9%
Driver 8	1	Leaflet	Long	Variance	3.5%	-3.7%
Driver 8	1	Leaflet	Average	Variance	7.0%	-6.8%
Driver 9	1	Instructor	Short	Variance	3.9%	-3.4%
Driver 9	1	Instructor	Long	Variance	3.8%	-3.8%
Driver 9	1	Instructor	Average	Variance	3.8%	-3.6%
Driver 10	1	Leaflet	Short	Variance	3.3%	-3.1%
Driver 10	1	Leaflet	Long	Variance	2.1%	-2.1%
Driver 10	1	Leaflet	Average	Variance	2.7%	-2.6%
Driver 11	2	Control	Short	Variance	2.4%	-2.4%
Driver 11	2	Control	Long	Variance	11.2%	-10.2%
Driver 11	2	Control	Average	Variance	6.8%	-6.3%

Driver 12	2	Control	Short	Variance	-1.6%	1.6%
Driver 12	2	Control	Long	Variance	-0.5%	0.3%
Driver 12	2	Control	Average	Variance	-1.0%	1.0%
Driver 13	2	Leaflet	Short	Variance	-0.4%	2.2%
Driver 13	2	Leaflet	Long	Variance	3.8%	-3.8%
Driver 13	2	Leaflet	Average	Variance	1.7%	-0.8%
Driver 14	2	Leaflet	Short	Variance	6.9%	-6.5%
Driver 14	2	Leaflet	Long	Variance	-1.3%	1.4%
Driver 14	2	Leaflet	Average	Variance	2.8%	-2.5%
Driver 15	2	Instructor	Short	Variance	19.6%	-16.7%
Driver 15	2	Instructor	Long	Variance	-0.3%	0.3%
Driver 15	2	Instructor	Average	Variance	9.6%	-8.2%
Driver 16	2	Control	Short	Variance	28.8%	-22.6%
Driver 16	2	Control	Long	Variance	-0.7%	0.8%
Driver 16	2	Control	Average	Variance	14.0%	-10.9%
Driver 17	2	Instructor	Short	Variance	41.9%	-29.6%
Driver 17	2	Instructor	Long	Variance	15.4%	-13.4%
Driver 17	2	Instructor	Average	Variance	28.7%	-21.5%
Driver 18	2	Leaflet	Short	Variance	-0.7%	0.7%
Driver 18	2	Leaflet	Long	Variance	5.8%	-5.5%
Driver 18	2	Leaflet	Average	Variance	2.6%	-2.4%

For each group, the proportion of drivers showing a beneficial response in fuel consumption to the intervention was as follows:

	Control	Leaflet	Instructor
Vehicle 1 (Euro 5)	1/3	2/3	2/3
Vehicle 2 (Euro 6)	2/3	3/3	3/3

Detailed results – CO_2 and CO

Driver	Vehicle	Group	Route	Test	CO_2	CO
					g/km	g/km
Driver 1	2	Instructor	Short	Before	131.4	0.079
Driver 1	2	Instructor	Short	After	121.7	0.049
Driver 1	2	Instructor	Long	Before	115.0	0.067
Driver 1	2	Instructor	Long	After	115.5	0.072
Driver 2	1	Instructor	Short	Before	143.1	0.211
Driver 2	1	Instructor	Short	After	151.3	0.162
Driver 2	1	Instructor	Long	Before	138.1	0.071
Driver 2	1	Instructor	Long	After	136.4	0.048
Driver 3	1	Control	Short	Before	140.6	0.220
Driver 3	1	Control	Short	After	171.7	0.143
Driver 3	1	Control	Long	Before	140.9	0.108
Driver 3	1	Control	Long	After	140.4	0.087
Driver 4	1	Leaflet	Short	Before	152.9	0.198
Driver 4	1	Leaflet	Short	After	164.6	0.210
Driver 4	1	Leaflet	Long	Before	146.0	0.087
Driver 4	1	Leaflet	Long	After	148.4	0.358
Driver 5	1	Instructor	Short	Before	155.1	0.160
Driver 5	1	Instructor	Short	After	143.8	0.182
Driver 5	1	Instructor	Long	Before	143.2	0.086
Driver 5	1	Instructor	Long	After	132.7	0.067
Driver 6	1	Control	Short	Before	140.3	0.124
Driver 6	1	Control	Short	After	152.6	0.212
Driver 6	1	Control	Long	Before	127.0	0.050
Driver 6	1	Control	Long	After	143.1	0.032
Driver 7	1	Control	Short	Before	156.1	0.168
Driver 7	1	Control	Short	After	151.7	0.122
Driver 7	1	Control	Long	Before	148.6	0.066
Driver 7	1	Control	Long	After	138.4	0.094
Driver 8	1	Leaflet	Short	Before	169.7	0.246
Driver 8	1	Leaflet	Short	After	152.5	0.181
Driver 8	1	Leaflet	Long	Before	139.1	0.110
Driver 8	1	Leaflet	Long	After	134.3	0.099
Driver 9	1	Instructor	Short	Before	140.7	0.086
Driver 9	1	Instructor	Short	After	136.1	0.112
Driver 9	1	Instructor	Long	Before	131.3	0.049
Driver 9	1	Instructor	Long	After	126.5	0.062

Driver 10	1	Leaflet	Short	Before	147.7	0.152
Driver 10	1	Leaflet	Short	After	143.3	0.144
Driver 10	1	Leaflet	Long	Before	138.8	0.104
Driver 10	1	Leaflet	Long	After	136.2	0.096
Driver 11	2	Control	Short	Before	140.7	0.033
Driver 11	2	Control	Short	After	137.1	0.077
Driver 11	2	Control	Long	Before	130.1	0.028
Driver 11	2	Control	Long	After	116.4	0.066
Driver 12	2	Control	Short	Before	139.0	0.058
Driver 12	2	Control	Short	After	141.7	0.101
Driver 12	2	Control	Long	Before	127.8	0.058
Driver 12	2	Control	Long	After	128.5	0.069
Driver 13	2	Leaflet	Short	Before	163.1	0.100
Driver 13	2	Leaflet	Short	After	166.4	0.041
Driver 13	2	Leaflet	Long	Before	136.0	0.075
Driver 13	2	Leaflet	Long	After	130.2	0.069
Driver 14	2	Leaflet	Short	Before	134.3	0.099
Driver 14	2	Leaflet	Short	After	125.3	0.109
Driver 14	2	Leaflet	Long	Before	117.0	0.090
Driver 14	2	Leaflet	Long	After	118.6	0.070
Driver 15	2	Instructor	Short	Before	157.7	0.102
Driver 15	2	Instructor	Short	After	130.8	0.129
Driver 15	2	Instructor	Long	Before	119.7	0.088
Driver 15	2	Instructor	Long	After	120.1	0.121
Driver 16	2	Control	Short	Before	176.8	0.118
Driver 16	2	Control	Short	After	136.2	0.074
Driver 16	2	Control	Long	Before	134.6	0.093
Driver 16	2	Control	Long	After	135.7	0.122
Driver 17	2	Instructor	Short	Before	196.6	0.134
Driver 17	2	Instructor	Short	After	136.8	0.084
Driver 17	2	Instructor	Long	Before	146.7	0.074
Driver 17	2	Instructor	Long	After	126.7	0.099
Driver 18	2	Instructor	Short	Before	124.0	0.111
Driver 18	2	Instructor	Short	After	125.2	0.066
Driver 18	2	Instructor	Long	Before	114.1	0.055
Driver 18	2	Instructor	Long	After	108.0	0.040

The table below summarises the variances between the groups.

Driver	Vehicle	Group	Route	Test	CO_2	CO
					g/km	g/km
Driver 1	2	Instructor	Short	Variance	-7.4%	-38.6%
Driver 1	2	Instructor	Long	Variance	0.4%	7.3%
Driver 1	2	Instructor	Average	Variance	-3.5%	-15.7%
Driver 2	1	Instructor	Short	Variance	5.8%	-23.1%
Driver 2	1	Instructor	Long	Variance	-1.2%	-33.3%
Driver 2	1	Instructor	Average	Variance	2.3%	-28.2%
Driver 3	1	Control	Short	Variance	22.1%	-34.8%
Driver 3	1	Control	Long	Variance	-0.4%	-20.1%
Driver 3	1	Control	Average	Variance	10.9%	-27.5%
Driver 4	1	Leaflet	Short	Variance	7.7%	6.3%
Driver 4	1	Leaflet	Long	Variance	1.6%	312.3%
Driver 4	1	Leaflet	Average	Variance	4.7%	159.3%
Driver 5	1	Instructor	Short	Variance	-7.3%	13.9%
Driver 5	1	Instructor	Long	Variance	-7.4%	-22.3%
Driver 5	1	Instructor	Average	Variance	-7.3%	-4.2%
Driver 6	1	Control	Short	Variance	8.8%	71.3%
Driver 6	1	Control	Long	Variance	12.7%	-36.3%
Driver 6	1	Control	Average	Variance	10.7%	17.5%
Driver 7	1	Control	Short	Variance	-2.8%	-27.4%
Driver 7	1	Control	Long	Variance	-6.9%	43.3%
Driver 7	1	Control	Average	Variance	-4.8%	7.9%
Driver 8	1	Leaflet	Short	Variance	-10.1%	-26.2%
Driver 8	1	Leaflet	Long	Variance	-3.5%	-9.7%
Driver 8	1	Leaflet	Average	Variance	-6.8%	-18.0%
Driver 9	1	Instructor	Short	Variance	-3.2%	30.1%
Driver 9	1	Instructor	Long	Variance	-3.7%	27.2%
Driver 9	1	Instructor	Average	Variance	-3.4%	28.7%
Driver 10	1	Leaflet	Short	Variance	-3.0%	-5.2%
Driver 10	1	Leaflet	Long	Variance	-1.9%	-7.9%
Driver 10	1	Leaflet	Average	Variance	-2.4%	-6.5%
Driver 11	2	Control	Short	Variance	-2.5%	135.1%
Driver 11	2	Control	Long	Variance	-10.5%	132.3%
Driver 11	2	Control	Average	Variance	-6.5%	133.7%

Driver 12	2	Control	Short	Variance	2.0%	74.2%
Driver 12	2	Control	Long	Variance	0.6%	18.3%
Driver 12	2	Control	Average	Variance	1.3%	46.3%
Driver 13	2	Leaflet	Short	Variance	2.0%	-58.8%
Driver 13	2	Leaflet	Long	Variance	-4.2%	-7.6%
Driver 13	2	Leaflet	Average	Variance	-1.1%	-33.2%
Driver 14	2	Leaflet	Short	Variance	-6.7%	10.6%
Driver 14	2	Leaflet	Long	Variance	1.4%	-22.4%
Driver 14	2	Leaflet	Average	Variance	-2.7%	-5.9%
Driver 15	2	Instructor	Short	Variance	-17.1%	26.6%
Driver 15	2	Instructor	Long	Variance	0.3%	38.4%
Driver 15	2	Instructor	Average	Variance	-8.4%	32.5%
Driver 16	2	Control	Short	Variance	-23.0%	-37.6%
Driver 16	2	Control	Long	Variance	0.8%	30.6%
Driver 16	2	Control	Average	Variance	-11.1%	-3.5%
Driver 17	2	Instructor	Short	Variance	-30.4%	-37.4%
Driver 17	2	Instructor	Long	Variance	-13.6%	32.5%
Driver 17	2	Instructor	Average	Variance	-22.0%	-2.5%
Driver 18	2	Leaflet	Short	Variance	1.0%	-40.7%
Driver 18	2	Leaflet	Long	Variance	-5.3%	-27.7%
Driver 18	2	Leaflet	Average	Variance	-2.2%	-34.2%

For each group, the proportion of drivers showing a beneficial response in CO emissions to the intervention was as follows:

	Control	Leaflet	Instructor
Vehicle 1 (Euro 5)	1/3	2/3	2/3
Vehicle 2 (Euro 6)	1/3	3/3	2/3

The result for CO_2 emissions follows fuel consumption, as shown above.

Detailed results – NO_x and NO_2

Driver	Vehicle	Group	Route	Test	NO_x	NO_2
					g/km	g/km
Driver 1	2	Instructor	Short	Before	1.068	0.323
Driver 1	2	Instructor	Short	After	0.766	0.287
Driver 1	2	Instructor	Long	Before	0.445	0.139
Driver 1	2	Instructor	Long	After	0.340	0.100
Driver 2	1	Instructor	Short	Before	1.133	0.130
Driver 2	1	Instructor	Short	After	0.920	0.025
Driver 2	1	Instructor	Long	Before	0.795	0.088
Driver 2	1	Instructor	Long	After	0.801	0.086
Driver 3	1	Control	Short	Before	0.870	0.081
Driver 3	1	Control	Short	After	1.017	0.078
Driver 3	1	Control	Long	Before	0.683	0.067
Driver 3	1	Control	Long	After	0.742	0.076
Driver 4	1	Leaflet	Short	Before	0.953	0.058
Driver 4	1	Leaflet	Short	After	1.070	0.053
Driver 4	1	Leaflet	Long	Before	0.843	0.085
Driver 4	1	Leaflet	Long	After	1.005	0.085
Driver 5	1	Instructor	Short	Before	1.029	0.065
Driver 5	1	Instructor	Short	After	0.991	0.059
Driver 5	1	Instructor	Long	Before	0.809	0.072
Driver 5	1	Instructor	Long	After	0.735	0.080
Driver 6	1	Control	Short	Before	0.928	0.094
Driver 6	1	Control	Short	After	0.997	0.080
Driver 6	1	Control	Long	Before	0.674	0.067
Driver 6	1	Control	Long	After	0.852	0.085
Driver 7	1	Control	Short	Before	1.078	0.063
Driver 7	1	Control	Short	After	1.082	0.094
Driver 7	1	Control	Long	Before	0.927	0.087
Driver 7	1	Control	Long	After	0.828	0.076
Driver 8	1	Leaflet	Short	Before	0.991	0.043
Driver 8	1	Leaflet	Short	After	0.972	0.071
Driver 8	1	Leaflet	Long	Before	0.741	0.082
Driver 8	1	Leaflet	Long	After	0.673	0.087
Driver 9	1	Instructor	Short	Before	0.909	0.073
Driver 9	1	Instructor	Short	After	0.854	0.051
Driver 9	1	Instructor	Long	Before	0.645	0.070
Driver 9	1	Instructor	Long	After	0.588	0.074

Driver 10	1	Leaflet	Short	Before	1.055	0.081
Driver 10	1	Leaflet	Short	After	1.030	0.068
Driver 10	1	Leaflet	Long	Before	0.796	0.089
Driver 10	1	Leaflet	Long	After	0.718	0.090
Driver 11	2	Control	Short	Before	1.166	0.326
Driver 11	2	Control	Short	After	0.991	0.274
Driver 11	2	Control	Long	Before	0.598	0.186
Driver 11	2	Control	Long	After	0.415	0.135
Driver 12	2	Control	Short	Before	1.060	0.321
Driver 12	2	Control	Short	After	1.280	0.338
Driver 12	2	Control	Long	Before	0.676	0.215
Driver 12	2	Control	Long	After	0.919	0.317
Driver 13	2	Leaflet	Short	Before	1.095	0.207
Driver 13	2	Leaflet	Short	After	0.785	0.136
Driver 13	2	Leaflet	Long	Before	0.598	0.179
Driver 13	2	Leaflet	Long	After	0.515	0.173
Driver 14	2	Leaflet	Short	Before	0.773	0.238
Driver 14	2	Leaflet	Short	After	0.873	0.281
Driver 14	2	Leaflet	Long	Before	0.358	0.113
Driver 14	2	Leaflet	Long	After	0.501	0.179
Driver 15	2	Instructor	Short	Before	1.032	0.186
Driver 15	2	Instructor	Short	After	1.308	0.391
Driver 15	2	Instructor	Long	Before	0.390	0.141
Driver 15	2	Instructor	Long	After	0.767	0.272
Driver 16	2	Control	Short	Before	1.049	0.132
Driver 16	2	Control	Short	After	1.220	0.402
Driver 16	2	Control	Long	Before	0.518	0.163
Driver 16	2	Control	Long	After	1.035	0.357
Driver 17	2	Instructor	Short	Before	0.953	0.073
Driver 17	2	Instructor	Short	After	1.336	0.422
Driver 17	2	Instructor	Long	Before	0.875	0.258
Driver 17	2	Instructor	Long	After	0.676	0.240
Driver 18	2	Instructor	Short	Before	0.859	0.176
Driver 18	2	Instructor	Short	After	0.731	0.127
Driver 18	2	Instructor	Long	Before	0.405	0.124
Driver 18	2	Instructor	Long	After	0.315	0.094

The table below summarises the variances between the groups.

Driver	Vehicle	Group	Route	Test	NO_x	NO_2
					g/km	g/km
Driver 1	2	Instructor	Short	Variance	-28.3%	-11.4%
Driver 1	2	Instructor	Long	Variance	-23.5%	-27.7%
Driver 1	2	Instructor	Average	Variance	-25.9%	-19.5%
Driver 2	1	Instructor	Short	Variance	-18.8%	-80.7%
Driver 2	1	Instructor	Long	Variance	0.8%	-2.1%
Driver 2	1	Instructor	Average	Variance	-9.0%	-41.4%
Driver 3	1	Control	Short	Variance	17.0%	-3.6%
Driver 3	1	Control	Long	Variance	8.7%	13.6%
Driver 3	1	Control	Average	Variance	12.8%	5.0%
Driver 4	1	Leaflet	Short	Variance	12.3%	-8.0%
Driver 4	1	Leaflet	Long	Variance	19.2%	0.6%
Driver 4	1	Leaflet	Average	Variance	15.7%	-3.7%
Driver 5	1	Instructor	Short	Variance	-3.7%	-9.4%
Driver 5	1	Instructor	Long	Variance	-9.1%	11.1%
Driver 5	1	Instructor	Average	Variance	-6.4%	0.9%
Driver 6	1	Control	Short	Variance	7.4%	-15.0%
Driver 6	1	Control	Long	Variance	26.3%	27.3%
Driver 6	1	Control	Average	Variance	16.9%	6.2%
Driver 7	1	Control	Short	Variance	0.4%	49.4%
Driver 7	1	Control	Long	Variance	-10.6%	-12.8%
Driver 7	1	Control	Average	Variance	-5.1%	18.3%
Driver 8	1	Leaflet	Short	Variance	-1.9%	66.3%
Driver 8	1	Leaflet	Long	Variance	-9.1%	6.5%
Driver 8	1	Leaflet	Average	Variance	-5.5%	36.4%
Driver 9	1	Instructor	Short	Variance	-6.1%	-29.9%
Driver 9	1	Instructor	Long	Variance	-8.9%	5.2%
Driver 9	1	Instructor	Average	Variance	-7.5%	-12.3%
Driver 10	1	Leaflet	Short	Variance	-2.3%	-16.5%
Driver 10	1	Leaflet	Long	Variance	-9.8%	0.2%
Driver 10	1	Leaflet	Average	Variance	-6.1%	-8.1%
Driver 11	2	Control	Short	Variance	-15.0%	-16.1%
Driver 11	2	Control	Long	Variance	-30.6%	-27.2%
Driver 11	2	Control	Average	Variance	-22.8%	-21.6%

Driver 12	2	Control	Short	Variance	20.7%	5.3%
Driver 12	2	Control	Long	Variance	36.0%	47.1%
Driver 12	2	Control	Average	Variance	28.3%	26.2%
Driver 13	2	Leaflet	Short	Variance	-28.3%	-34.4%
Driver 13	2	Leaflet	Long	Variance	-13.9%	-3.1%
Driver 13	2	Leaflet	Average	Variance	-21.1%	-18.7%
Driver 14	2	Leaflet	Short	Variance	12.8%	18.0%
Driver 14	2	Leaflet	Long	Variance	39.8%	57.8%
Driver 14	2	Leaflet	Average	Variance	26.3%	37.9%
Driver 15	2	Instructor	Short	Variance	26.8%	109.5%
Driver 15	2	Instructor	Long	Variance	96.7%	92.7%
Driver 15	2	Instructor	Average	Variance	61.8%	101.1%
Driver 16	2	Control	Short	Variance	16.3%	203.5%
Driver 16	2	Control	Long	Variance	99.9%	118.8%
Driver 16	2	Control	Average	Variance	58.1%	161.1%
Driver 17	2	Instructor	Short	Variance	40.2%	481.6%
Driver 17	2	Instructor	Long	Variance	-22.8%	-7.1%
Driver 17	2	Instructor	Average	Variance	8.7%	237.3%
Driver 18	2	Leaflet	Short	Variance	-14.9%	-27.7%
Driver 18	2	Leaflet	Long	Variance	-22.2%	-23.8%
Driver 18	2	Leaflet	Average	Variance	-18.5%	-25.7%

For each group, the proportion of drivers showing a beneficial response in NO_x emissions to the intervention was as follows:

	Control	Leaflet	Instructor
Vehicle 1 (Euro 5)	1/3	2/3	3/3
Vehicle 2 (Euro 6)	1/3	2/3	1/3

Appendix 1 – Equipment Specification

The span values calibrated to were:

Channel	Unit	Value
CO	ppm	1212
CO_2	%	12
O_2	%	20.9
HC	ppm	2010
NO	ppm	1495
NO_2	ppm	249
THC	ppm	244.2

Appendix 2 – Calibration Certificates

Sensors, Inc.
6812 State Road
Saline, MI 48176

Certificate No.	4125
Issue date:	10-Oct-17

SEMTECH LDV CERTIFICATE OF COMPLIANCE

This document certifies that the PEMS listed below meets the audit requirements of RDE 692/2008 as indicated. Testing was performed using procedures specified in RDE with equipment traceable to the National Institute of Standards (NIST). The PEMS listed below is in compliance with UN/ECE regulations.

SEMTECH LDV Instrument information:

LDV SCS Module S/N: I17139427
Software Version: 17.01B

692/2008 Subpart	Description	Test date	Due date	Pass/Fail
Appx. 1, 4.1	Leak Check of SCS	24-Oct-17	initial installation or major maintenance	Pass
Appx. 2, 4.4	System Response Time -CO/CO_2	24-Oct-17	initial installation or major maintenance	Pass
Appx. 2, 4.4	System Response Time -NO/NO_2	24-Oct-17	initial installation or major maintenance	Pass
Appx. 2, 4.3.5(f)	Sample dryer NO_2 penetration	17-Oct-17	initial installation or major maintenance	Pass
Appx. 2, 8 (Table 4)	Accuracy of ambient pressure sensor	11-Oct-17	initial installation or major maintenance	Pass
Appx. 2, 8 (Table 4)	Accuracy of internal RH sensor	10-Oct-17	initial installation or major maintenance	Pass
Appx. 2, 8 (Table 4)	Accuracy of internal temperature sensor	10-Oct-17	initial installation or major maintenance	Pass

Technician: James Gallagher Date: 10-25-17

Q.A.: Date: 10-25-17

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Sensors, Inc.
6812 State Road
Saline, MI 48176

Certificate No.	4125
Issue date:	10-Oct-17

SEMTECH LDV CERTIFICATE OF COMPLIANCE

SEMTECH LDV Instrument information:

LDV SCS Module S/N: I17139427

Software Version: 17.01B

Traceability of Gas Standards

Gas Bottle Description	Supplier	Cylinder #	Stated Accuracy	Expiration Date
16.21 % CO_2, 4979 ppm CO, 992.2 ppm NO, 300.3 ppm Propane, balance N_2	Air Gas	CC406558	±1%	4-Aug-25
510 ppm NO_2, balance Air	Air Gas	CC420184	±1%	1-May-20

Equipment Traceability

Model	S/N	Calibration Date	Calibration Due Date	Certificate Number
Vaisala	L4540035	14-Feb-17	14-Feb-18	3444
Digitron 2082P	DPM-004	8-Aug-17	8-Aug-18	3982110001

Sensors, Inc.
6812 State Road
Saline, MI 48176

Certificate No.	**4126**
Issue date:	**11-Oct-17**

SEMTECH LDV CERTIFICATE OF COMPLIANCE

This document certifies that the PEMS listed below meets the audit requirements of RDE 692/2008 as indicated. Testing was performed using procedures specified in RDE with equipment traceable to the National Institute of Standards (NIST). The PEMS listed below is in compliance with UN/ECE regulations.

SEMTECH LDV Instrument information:

LDV GAS Module S/N:	J17139454
NDIR Analyzer S/N:	I17500772
NDUV Analyzer S/N:	I17139417
Software Version:	17.01B

692/2008 Subpart	Description	Test date	Due date	Pass/Fail
Appx. 2, 4.2.2	CO/CO_2 analyzer Accuracy	18-Oct-17	initial installation or major maintenance	Pass
Appx. 2, 4.2.2	NO/NO_2 analyzer Accuracy	16-Oct-17	initial installation or major maintenance	Pass
Appx. 2, 4.2.3	CO/CO_2 analyzer Precision	18-Oct-17	initial installation or major maintenance	Pass
Appx. 2, 4.2.3	NO/NO_2 analyzer Precision	17-Oct-17	initial installation or major maintenance	Pass
Appx. 2, 4.2.4	CO/CO_2 analyzer Noise	18-Oct-17	initial installation or major maintenance	Pass
Appx. 2, 4.2.4	NO/NO_2 analyzer Noise	17-Oct-17	initial installation or major maintenance	Pass
Appx. 2, 4.2.5	CO/CO_2 analyzer Zero response drift	19-Oct-17	initial installation or major maintenance	Pass
Appx. 2, 4.2.5	NO/NO_2 analyzer Zero response drift	19-Oct-17	initial installation or major maintenance	Pass
Appx. 2, 4.2.6	CO/CO_2 analyzer Span response drift	19-Oct-17	initial installation or major maintenance	Pass
Appx. 2, 4.2.6	NO/NO_2 analyzer Span response drift	19-Oct-17	initial installation or major maintenance	Pass
Appx. 2, 4.2.7	CO/CO_2 Rise Time	24-Oct-17	initial installation or major maintenance	Pass
Appx. 2, 4.2.7	NO/NO_2 Rise Time	24-Oct-17	initial installation or major maintenance	Pass

Sensors, Inc.
6812 South State Road
Saline, Michigan 48176

Certificate No.	**4126**
Issue date:	**11-Oct-17**

Certificate of Compliance

LDV GAS Module S/N:	J17139454
NDIR Analyzer S/N:	I17500772
NDUV Analyzer S/N:	I17139417
Software Version:	17.01B

692/2008 Subpart	Description	Test date	Due date	Pass/Fail
Appx. 2, 4.4	CO/CO_2 System Response Time	24-Oct-17	initial installation or major maintenance	Pass
Appx. 2, 4.4	NO/NO_2 System Response Time	24-Oct-17	initial installation or major maintenance	Pass
Appx. 1, 4.1	Leak Check of PEMS system	24-Oct-17	initial installation or major maintenance	Pass
Appx. 2, 4.3.5(b)	H_2O and CO_2 interference verification for CO NDIR analyzers	24-Oct-17	initial installation or major maintenance	Pass
Appx. 2, 4.3.5(d)	Quench check for NDUV analyzers	11-Oct-17	initial installation or major maintenance	Pass

Technician: James Gallagher Date: 10-25-17

Q.A.: Date: 10-25-17

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Sensors, Inc.
6812 State Road
Saline, MI 48176

Certificate No.	4126
Issue date:	11-Oct-17

SEMTECH LDV CERTIFICATE OF COMPLIANCE

SEMTECH LDV Instrument information:

LDV GAS Module S/N: J17139454
NDIR Analyzer S/N: I17500772
NDUV Analyzer S/N: I17139417
Software Version: 17.01B

Traceability of Gas Standards

Gas Bottle Description	Supplier	Cylinder #	Stated Accuracy	Expiration Date
16.21 % CO_2, 4979 ppm CO, 992.2 ppm NO, 300.3 ppm Propane, balance N_2	Air Gas	CC406558	±1%	4-Aug-25
6.054 % CO_2, 4960 ppm CO, 297.7 ppm NO, 203.3 ppm Propane, balance N_2	Air Gas	CC104680	±1%	13-Sep-24
12.15 % CO_2, 81120 ppm CO, 3028 ppm NO, 3261 ppm Propane, balance N_2	Air Gas	CC406525	±1%	8-Dec-24
16.19 % CO_2, balance N_2	Air Gas	W343751	±1%	22-Aug-24
510 ppm NO_2, balance Air	Air Gas	CC420184	±1%	1-May-20
1018 ppm NO_2, balance Air	Air Gas	CC201322	±1%	31-Jan-20

Equipment Traceability

Model	S/N	Calibration Date	Calibration Due Date	Certificate Number
Horiba SGD-710C	GDU-001	17-Nov-16	17-Nov-17	G0000YFR-111716
Horiba SGD-710C	GDU-002	25-Aug-17	25-Aug-18	F0F00T0R-082517

Appendix 3 – Test route

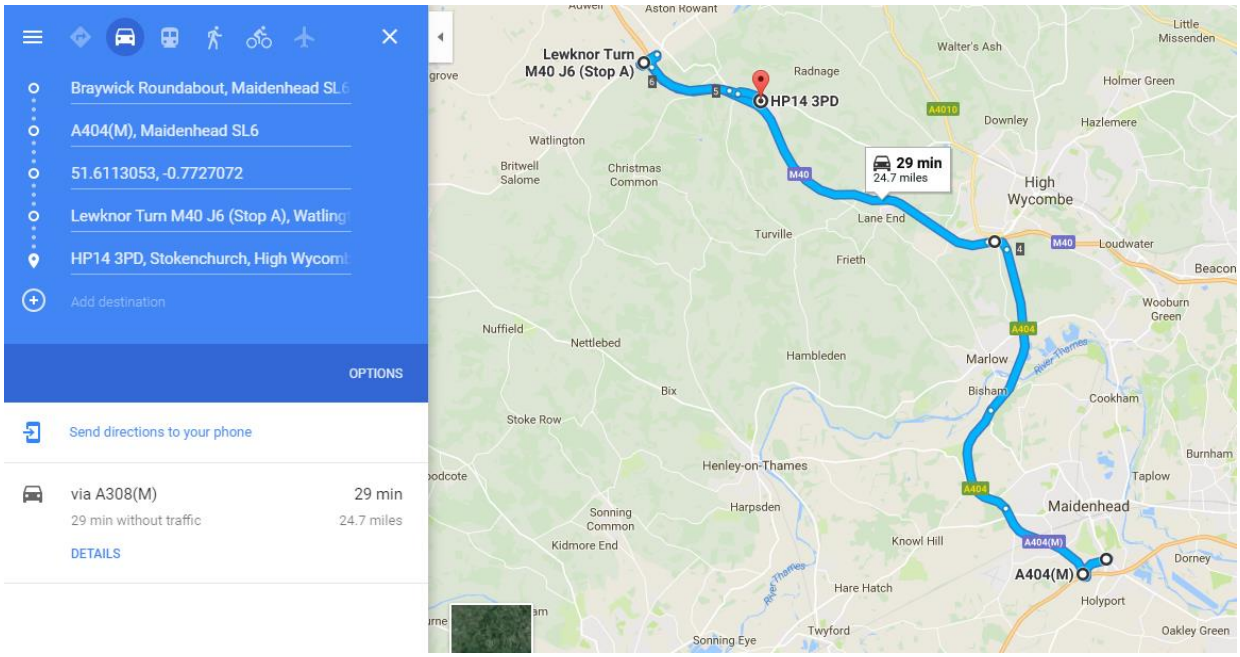
The cartographical route was as follows.

Segment Type	Start location	End location	Target repeats	Typical duration per repeat	Typical total duration	Engine temp at start
Short motorway	HP14 3PD	HP14 3PD	2	41	82	Warm
Long motorway	HP14 3PD	HP14 3PD	2	7	14	Warm

Typical test duration: 1 hours 36 mins

The start and finish of each segment is the same, meaning that each is a complete loop, not a drive from A to B.

Test Route: https://goo.gl/UxXU76



Appendix 4 – Test vehicle specifications

	KM58 HCU	YR16 XNY
Make	Ford	Ford
Model	Focus	Focus
VRM	KM58 HCU	YR16 XNY
Euro stage	5	6
Date of Registration	18/11/2008	31/03/2016
Gross Vehicle Weight (kg)	1885	1900
Kerbside Weight (kg)	1391	1343
Body Type	Estate	Hatchback
Engine Type Designation	TDCi	TDCi
Emission Control Strategy	Diesel Particulate Filter	Lean NO_x Trap, Diesel Particulate Filter
Fuel Type	Diesel	Diesel
Engine Swept Volume (cc)	1560	1498
Engine Max Power Output (bhp)	109	120
Engine Max Torque Output (lb/ft)	177	199
Transmission	Manual	Manual
Official fuel economy (mpg)		
Urban	48.7	65.7
Extra Urban	74.3	83.1
Combined	62.8	74.3


NAU
KM58 HCU