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Hayden Padden Fuel Challenge

Prepared for:
Z Energy Ltd

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18 September 2012

Project No. 32041.001

Contents

1. Introduction

Utilising the services of rally driver Hayden Padden and his navigator/co-driver John Kennard, Z Energy commissioned Auckland UniServices to undertake and monitor a series of tests using identical cars to compare ZX 95 petrol with another industry 95 octane and an industry 98 octane petrol.

The cars used were Skoda Octavia TSI 90 wagons fitted with 1.4L turbocharged, direct injection engines with 7 speed DSG gearboxes. Fuller specifications of the cars are given in Appendix 1.

All measurements taken in the programme were taken by UniServices personnel and the fuels used were either purchased direct by or overseen by UniServices personnel.

The programme consisted of three phases:

a. Power, exhaust emissions and fuel consumption testing on the University of Auckland's chassis dynamometer
b. Fuel consumption measurements – Auckland to Taupo and Taupo to Wellington
c. Timed acceleration runs at Taupo Motorsport Park

2. Chassis Dynamometer Power, Fuel Consumption and Emissions Comparison

The objectives of the chassis dynamometer tests were twofold:

a. To ensure that the performance characteristics of the two cars were sufficiently similar to be able to accurately compare the fuel consumptions of the three fuels
b. To compare full throttle power and part load fuel consumption and exhaust emissions on one car using the three fuels.

To achieve this, the following test sequence was undertaken:

- Power, emissions and fuel consumption on Car 1, registration number GKN 577, using ZX fuel
- Power, emissions and fuel consumption on Car 2, registration number GHP 686, using XZ, industry 95 and industry 98 fuels

The power tests measured full throttle power in 3rd gear from 3500 to 6000 rev/min, which equated to a road speed range of approximately 65 km/h to 98 km/h. It was not possible to test at a lower speed than this due to the gearbox kicking down into 2nd gear, creating a dangerous condition on the dynamometer.

For the exhaust emissions and fuel consumption tests, both a transient drive cycle and steady speeds were used. The drive cycle was the IM240, which is a 240 second portion of the US Federal FTP 75 cycle, and is used for Inspection and Maintenance emissions testing in the US. The profile of the IM240 cycle is given in Appendix 2. The steady speeds were 50 km/h and 100 km/h.

Exhaust emissions of CO, HC, NO_X and CO_2 were measured using the Constant Volume Sampling technique and processed to give results in g/km units. Fuel consumption was calculated in L/100km units from the emissions data using a carbon balance methodology.

As a cross check on the fuel consumption results, both vehicles were fitted with Auterra *DashDynos,* details of which are given in Appendix 3. These were left in place for the duration of the programme and were used for the acceleration runs at Taupo and as one of the two methods used for monitoring the fuel consumption over the road trip.

2.1 Test Results and Discussion

The power curves for the two vehicles on the three fuels are shown in Figures 1 and 2.

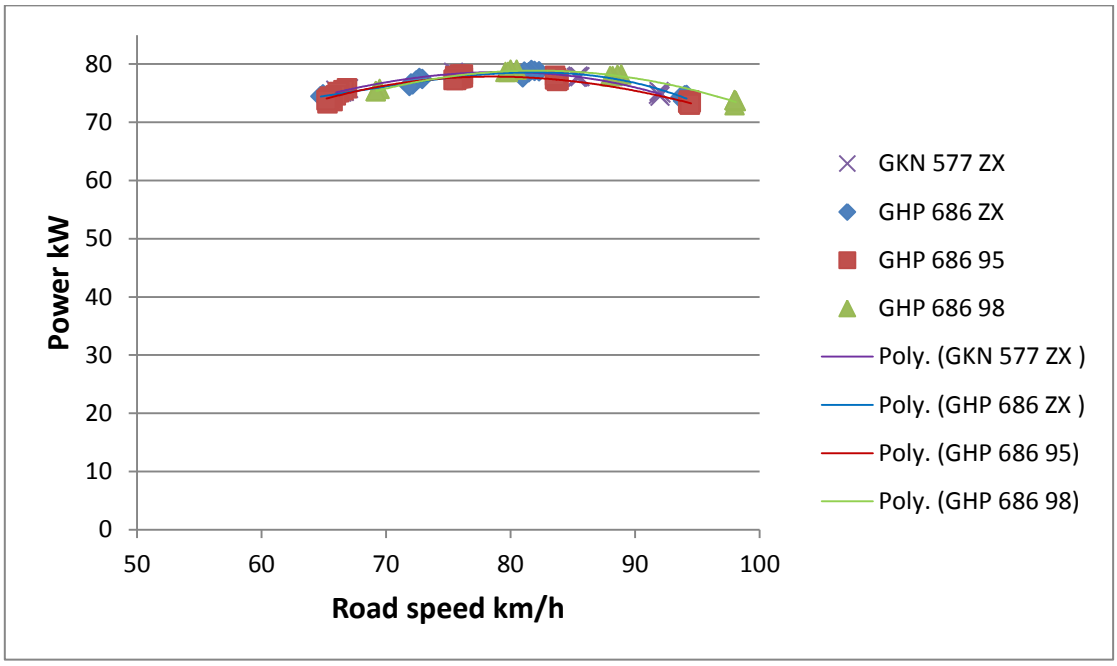


Figure 1: Full throttle power output

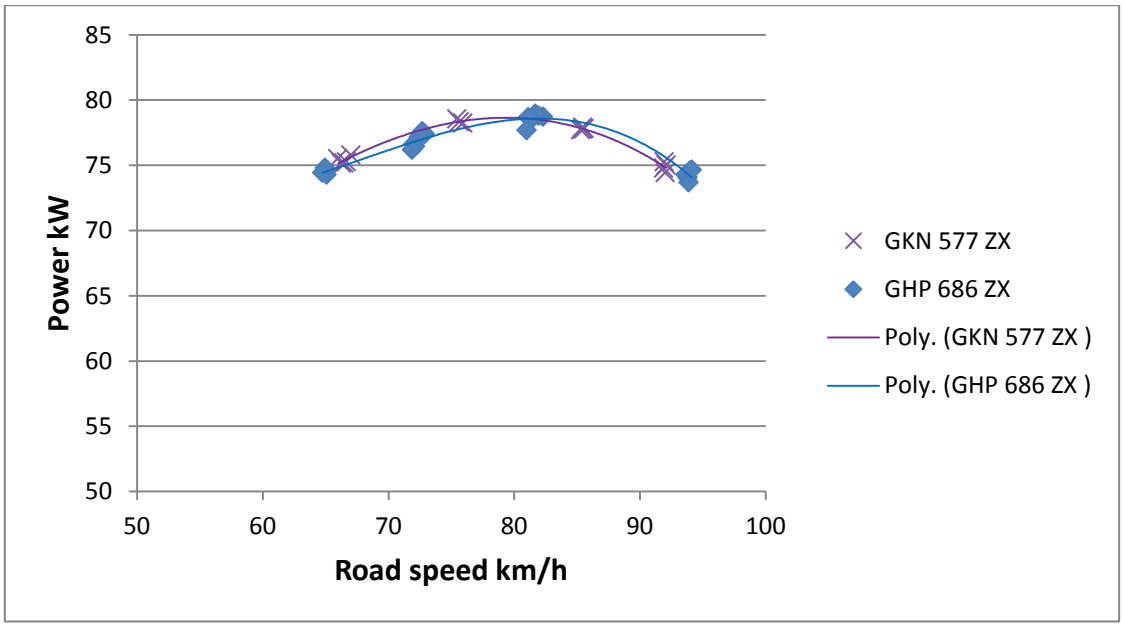


Figure 2: Full throttle power output – ZX fuel, expanded scale

As can be seen in graphs, there was very little difference in the power output of the two vehicles on ZX fuel, and between ZX and industry 95 fuel on Car 2. Industry 98 fuel appeared to produce slightly more power at the upper end of the speed range, which was not unexpected given that these vehicle are equipped with ignition systems that are knock (detonation) limited. Consequently, the 98 octane fuel allowed greater ignition advance, producing more power.

The emissions and fuel consumption results for the two vehicles on the three fuels are shown in Table 1. Tests were repeated at least three times for each fuel to ensure acceptable consistency of results. The figures in Table 1 are the averages.

Table 1: Chassis dynamometer emissions and fuel consumption

Test			**Car 1 (GKN577)**	**Car 2 (GHP686)**		
			Fuel	**Fuel**		
			ZX	**ZX**	**Ind 95**	**Ind 98**
IM240	CO g/km		0.219	0.073	0.093	0.083
	HC g/km		0.006	0.003	0.002	0.001
	NO_X g/km		0.039	0.005	0.020	0.001
	Fuel Cons L/100km	CB	7.59	7.25	7.37	7.71
	Fuel Cons L/100km	DD	7.64	7.40	7.58	7.60
50km/h	CO g/km		0.028	0.028	0.055	0.028
	HC g/km		0.001	0.002	0.001	0.001
	NO_X g/km		0.001	n/m	n/m	0.002
	Fuel Cons L/100km	CB	4.38	4.26	4.27	4.53
	Fuel Cons L/100km	DD	4.91	4.58	4.85	4.58
100km/h	CO g/km		0.172	0.133	0.160	0.126
	HC g/km		0.008	0.005	0.006	0.006
	NO_X g/km		0.002	n/m	n/m	n/m
	Fuel Cons L/100km	CB	7.59	7.23	7.48	7.36
	Fuel Cons L/100km	DD	7.52	7.65	7.58	7.50

CB = Carbon Balance, DD = DashDyno, n/m = not measurable

Comparison of the fuel consumptions for both vehicles on ZX fuel indicated that Car 1 had a slightly higher consumption than Car 2, in the range 3% to 4%.

The fuel consumption as measured by the DashDyno was, in most cases, higher than that measured by the Carbon Balance method from the emissions, in the range 2% to 12%.

Comparison of the three fuels on car 2 indicated that ZX provided the lowest fuel consumption, with industry 98 being the highest over the IM240 cycle and at 50 km/h.

Exhaust emissions rates were very low for all conditions and there were no significant trends between the three fuels.

3. Road Trip Fuel Consumption Comparison

In order to maximise the accuracy of the road trip fuel consumption comparison results, a number conditions were applied:

- The weight of the two vehicles were made as close as possible. Hayden and his partner Katie travelled together in one car. To match the weights, John carried luggage in his.
- The vehicles were required to travel one behind the other, but not so close that the second car would benefit from the slipstream of the first.
- Overtaking was to be planned so that both vehicles could overtake together
- Idling periods were to be the same
- Both vehicles were drive in automatic mode (D7)
- The tyre pressures were set the same on both cars
- The windows were closed at all times with the climate control air conditioning on at the same setting.
- The drivers interchanged cars once on each leg (at Putararu on the Auckland – Taupo leg and Hunterville on the Taupo – Wellington leg).
- All fuelling/refuelling was carried out on a level surface, using manual filling from containers by the same person to ensure consistency of procedure.

The fuel consumption measurement procedure was as follows:

a. Both vehicles were fully fuelled at the University of Auckland, Faculty of Engineering. Car 1 was filled with ZX and car 2 with industry 98. The vehicles' trip meters and the DashDynos were zeroed.
b. Upon arrival in Taupo both vehicles were refuelled at the same location with their respective fuels to the same level as in Auckland, with the weights of the fuels being recorded. The densities of the fuels were measured and the weights converted to volumetric units. The trip meters and DashDyno readings were recorded.
c. Prior to leaving Taupo both vehicles were fully filled, car 1 with ZX and car 2 with industry 95 (after having drained all the 98 at Taupo Motorsport Park). Trip meters and DashDynos were reset to zero.
d. On arrival in Wellington both vehicles were refuelled in the same manner as for Taupo. Trip meters and DashDyno readings were again recorded.

3.1 Results and Discussion

The fuel consumption rates measured for the two legs for the two cars are shown in Table 2.

Full details of all measurements are given in Appendix 4.

Table 2: Road Trip Fuel Consumption

Auckland to Taupo				
Car	Fuel	Litres	L/100 km (Trip)	L/100 km (DD)
1	ZX	19.742	6.55	6.58
2	Ind 98	20.258	6.72	6.77

Taupo to Wellington				
Car	Fuel	Litres	L/100 km (Trip)	L/100 km (DD)
1	ZX	24.291	6.40	6.44
2	Ind 95	24.545	6.45	6.45

On the Auckland to Taupo leg the fuel consumption of Car 1 using ZX fuel was 2.5% to 2.8% less than Car 2 using industry 98 fuel, depending on which distance measurement method is used.

On the Taupo to Wellington leg the fuel consumption of Car 1 using ZX fuel was marginally lower than Car 2 using industry 95, but the difference was so small as to be considered insignificant.

These trends are consistent with the dynamometer test results which found the industry 98 fuel to provide the highest fuel consumption and ZX the lowest.

The dynamometer tests indicated that the fuel consumption of Car 2 was around 3% higher than Car 1 for the same fuel and driving conditions. Factoring this into the road trip results would indicate that the fuel consumption with ZX was around 3% lower than industry 95 and around 5% lower that industry 98.

4. Acceleration Comparisons

At Taupo Motorsport Park, two tests were undertaken:

- Side-by-side “drag” runs comparing Car 1 using ZX with Car 2 using both industry 95 and 98. The vehicles were driven in auto mode to eliminate possible gear shift variations. The DashDynos were used to record the acceleration characteristics – speed and distance – of both cars. Repeat runs were undertaken for each fuel/car to ensure consistency of results.
- Circuits of Track 2 by both Hayden and John using both cars with the three fuels to subjectively assess the performance of the fuels.

Figures 3, 4 and 5 show typical speed - time traces for the three fuels.

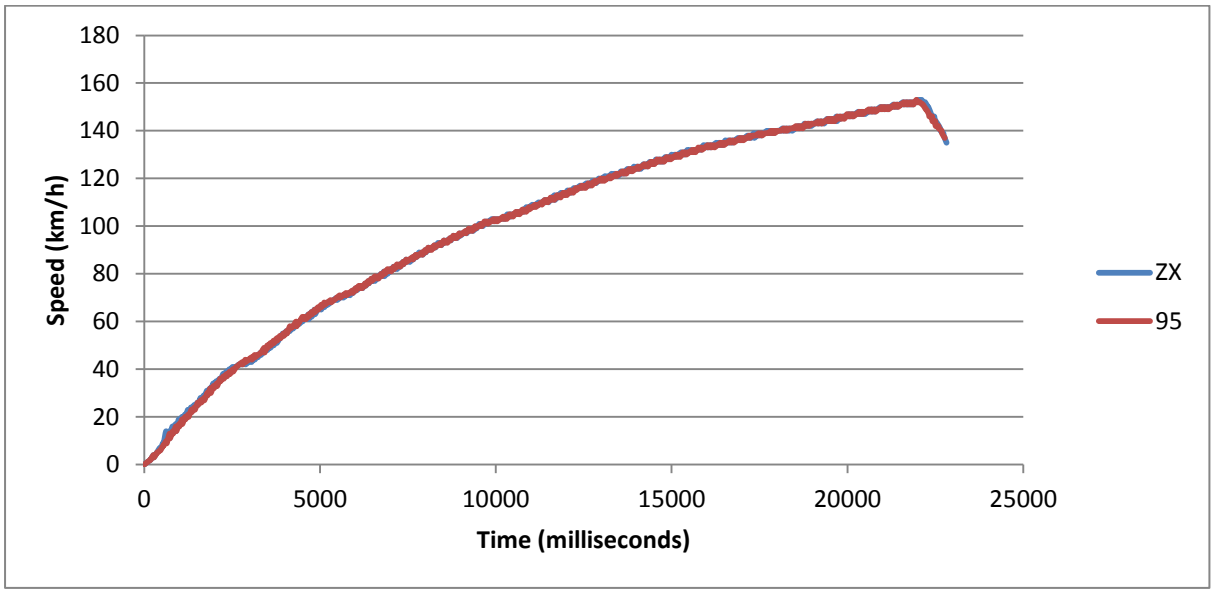


Figure 3: Acceleration comparisons of ZX and industry 95.

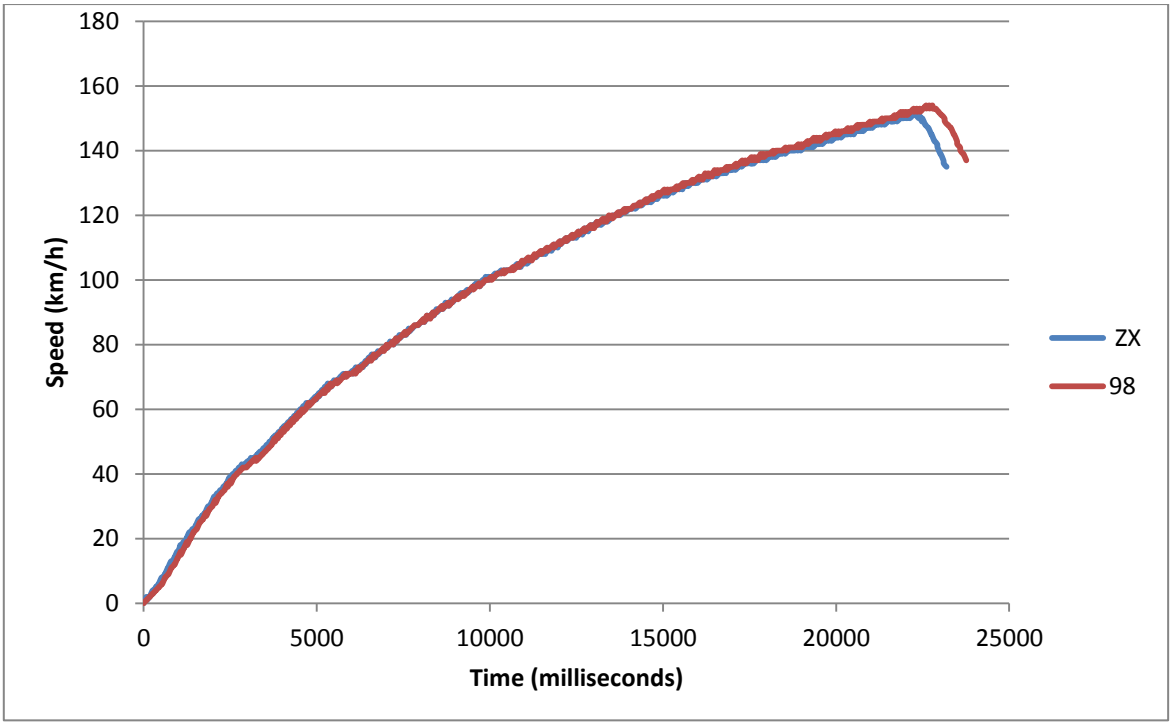


Figure 4: Acceleration comparisons of ZX and industry 98.

From the graphs there does not appear to be any noticeable difference in acceleration rates between ZX and the other two fuels. However, observers at the start line commented that the ZX vehicle appeared to accelerate slightly quicker than the 98 vehicle in the initial phase. By expanding the scale for the first 5 seconds of the run, as shown in Figure x, it can be seen that the ZX vehicle was approximately 0.2 seconds quicker to 20km/h. As the speeds increased the difference reduced so that by 40km/h the times were the same.

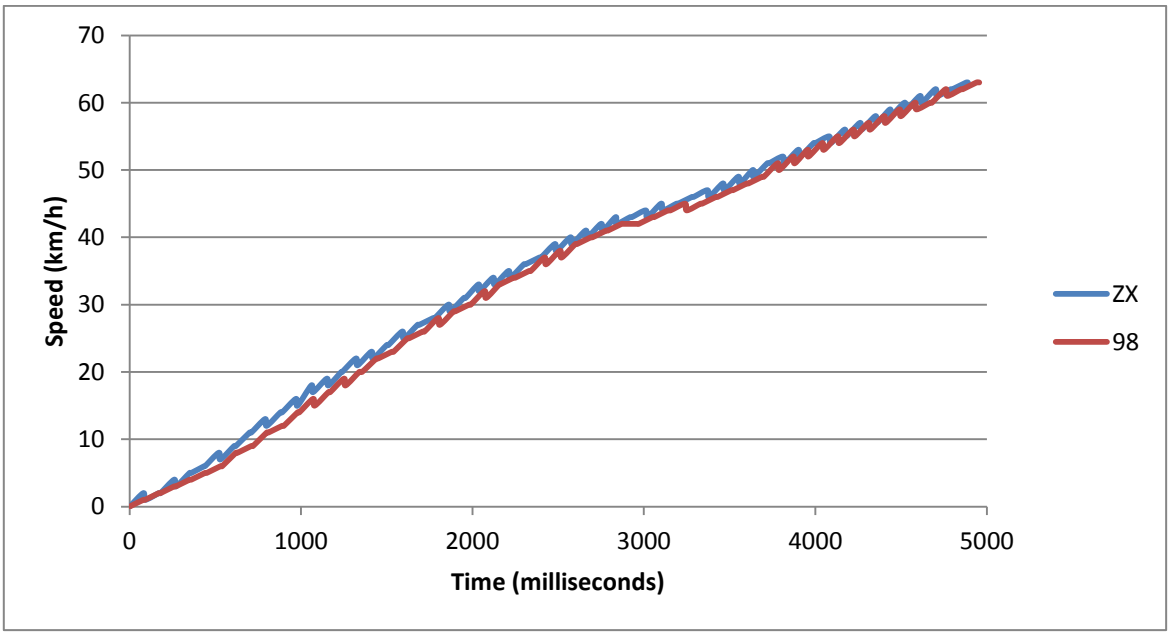


Figure 5: Acceleration comparisons of ZX and industry 98, first 5 seconds.

5. Conclusions

The findings of the test programme were as follows:

- Full throttle power output with ZX and industry 95 fuels were comparable
- Power out with industry 98 fuel was slightly higher than with ZX, but this was most probably due to the type of ignition system used on the test vehicles.
- Exhaust emissions rates on all the fuels were very low and there were no significant differences between the three fuels.
- Fuel consumption over the road trip was lowest with ZX, with 95 and 98 being respectively 3% and 5% higher.
- Full throttle acceleration rates with ZX and industry 95 were almost identical.
- The initial acceleration rate with ZX was marginally faster than with industry 98, with 98 being better at speeds above 120km/h.

Appendix 1: Skoda Octavia Wagon Specifications

SIMPLY CLEVER

ŠKODA

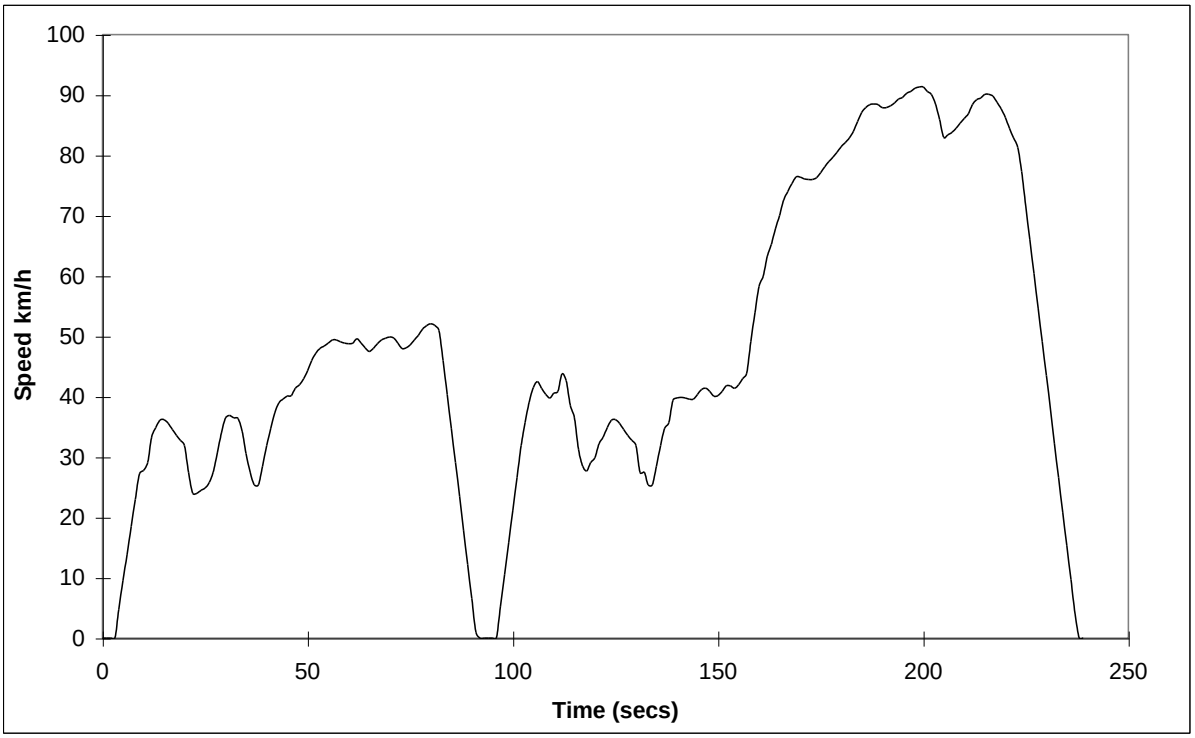
ŠKODA Octavia Wagon Specification

Model Year 2012

Issued: February 2012

Octavia Wagon	TSI 90	TDI 77	TSI 118
Recommend Retail Price *			
Manual	$37,000	$39,000	-
Automatic	$39,500	$41,500	$44,000
Technical Data			
Engine Type	Turbo Petrol	Turbo Diesel	Turbo Petrol
Displacement (cm^3)	1,390	1,598	1,798
Power Output - kW @ rpm	90 @ 5,000	77 @ 4,400	118 @ 4,500 - 6,200
Torque - Nm @ rpm	200 @ 1,500 - 4,000	250 @ 1,500 - 2,500	250 @ 1,500 - 4,500
Cylinders	4	4	4
Drive train	Front Wheel Drive	Front Wheel Drive	Front Wheel Drive
Transmission - manual	5 speed Manual	5 speed Manual	N/A
Transmission - automatic	7 speed DSG	7 speed DSG	7 speed DSG
Efficiency			
Fuel Economy - EU, In Town (Litres/100km)	8.5 (8.0)	5.7 (5.6)	9.1
Fuel Economy - EU, Out of Town (Litres/100km)	5.0 (5.3)	3.9 (4.2)	5.4
Fuel Economy - EU, Combined (Litres/100km)	6.3 (6.3)	4.5 (4.7)	6.6
CO_2 Emissions (g/km)	148 (147)	119 (123)	155
Diesel Particulate Filter	N/A	std	N/A
Emissions Standard	EU5	EU5	EU5
Performance			
0-100 km/ h in seconds	9.8 (9.8)	11.9 (12.1)	7.9
Maximum speed in km/h	202 (201)	189 (189)	222
Drag Coefficient	0.30	0.30	0.30
Dimensions			
Length (mm)	4,569	4,569	4,569
Width (mm)	1,769	1,769	1,769
Height (mm)	1,468	1,468	1,468
Luggage Capacity (litres)	580 / 1,620	580 / 1,620	580 / 1,620
Fuel Capacity (litres)	55	55	55

Appendix 2: IM240 Drive Cycle



Appendix 3: Auterra Dash Dyno

DashDyno SPD ProPack

DashDyno SPD™ combines a scan tool, performance meter and data logger into one, easy-to-use instrument for the automotive enthusiast. Measure instant and average fuel economy, data log engine sensors and GPS position, measure horsepower and torque, trigger alarms lights, read/clear your dashboard Check Engine light and more. Access to thousands of generic and enhanced diagnostic trouble code definitions displayed directly on screen. Recorded data may be viewed directly on DashDyno or using a PC with the included Dyno-Scan for Windows software.

English and Metric units of measure supported. The software supports a PC with Windows XP/Vista/7 or Macintosh computer running Parallels Desktop for Mac.

Connect a Windows PC to your vehicle. Use the DashDyno pass-through mode and the included Dyno-Scan for Windows software to perform advanced vehicle diagnostics. DashDyno is a handheld, in-vehicle display and PC-based scan tool all-in-one!

Package Contents

The A-501 DashDyno SPD ProPack kit includes:

- DashDyno SPD
- DashDyno SPD Software CD ROM (S-102)
- Dyno-Scan for Windows software
- OBD II Cable (O-102)
- DashDyno Serial GPS Cable (C-160)
- USB Cable A to Mini-B (C-152)
- Quick Release Suction Cup Windshield Mount (C-200)
- Female Quick Release Mounting Screws
- AC Adapter (C-201)
- Cable Tie
- Quick Start Guide
- Electronic User Manual

Key Features

- All 1996 and later vehicles supported, including American, Asian, and European
- Windows XP, Vista and Windows 7 Supported (32-bit and 64-bit, all versions)
- Easy installation - no hard wiring required
- 280 selectable parameters and simultaneously record up to 16
- English and Metric units of measure.
- Enhanced OBD II parameters
- Includes Dyno-Scan for Windows software for PC-based diagnostics
- Can be dash mounted or handheld
- Quick release windshield mount option
- Powerful 32-bit microprocessor
- SD / MMC card slot for recording data
- Auto-Record feature for no-touch, long-term recording over days, weeks or months

- Backlit high-contrast LCD display with temperature contrast compensation
- Auto power-on when vehicle is started
- Trip computer with instant and average fuel economy
- Record GPS data using an external GPS receiver
- View GPS data within Google Earth
- TrackVision data file export for making in-car videos (TrackVision sold separately)
- Powered from an OBD II cable or A/C adapter
- Measures Horsepower and Torque corrected per SAE 1349
- 0-60mph, 1/8 and 1/4 mile, and top speed
- Playback recorded data and use fast forward/reverse for quick navigation
- Three user programmable alarm lights
- Record / play and keyboard shift key indicator lights
- 8 button backlit keypad with secondary functions
- USB port for connection to a PC
- Two expansion ports for optional accessories and sensor logging
- Four external analog inputs, a digital input, a digital output, and a serial port
- Analog input range select (0-6V, 0-12V and 0-24V)
- 2-channel digital oscilloscope mode
- Customizable sensor conversion formulas
- Software wizards offer step by step guidance
- Corrects measurements for inaccurate speedometer due to non-stock tire size
- Read and clear diagnostic trouble codes
- Enhanced and generic code definitions displayed on screen
- Turn off Check Engine or Service Engine Soon light
- Line graphs, bar graphs, meters and gauges
- All graph screens zoom in/out and scroll right/left/up/down
- Axis labels auto-hide after 3 seconds providing unobstructed graph views
- Min/max axis labels update with zoom and scroll
- 256-point per channel buffer on graph screens
- J1850 (VPW, PWM), ISO 9141, ISO 14320 (KWP), and ISO 15765 (CAN bus) protocols
- CAN bus 6x mode reads six sensors at once from the vehicle
- Easy installation - plugs into the vehicle OBD II diagnostic port
- Low-profile OBD II cable connector

Appendix 4: Road Trip Fuel Consumption Test Results

Date:	20/08/2012		
Fuel Type	Industry 98	**Driver**	John to Putararu/Hayden to Taupo
Vehicle:	Skoda	**Plate No**	GHP 686

Tyre Pressures	Front		Rear	
	L	R	L	R
Start	32	32	30.5	30.5
Finish	32	31	30	30

Vehicle Data

Odometer start:	2295	km
Odometer finish:	2597	km
Trip distance:	301.5	km

DashDyno Data

Average Economy	6.9
Fuel Used	20.74
Average Speed	70.5
Distance Travelled	299.2
Drive Time	4.14
Idle Time	0.2
Idle Time %	8.1

Refuelling

Container Tare weight	1.792	kg
Fuel Density	0.7455	kg/l
Fuel Temperature	13.7 - 14.3	°C

Weighed amounts	1	2	Brim	Brim
	kg	kg	kg	kg
Full weight	16.236		2.138	
Empty weight	2.762		0.51	
Amount	13.474		1.628	
Calculated volume	18.074		2.184	

Total volume	20.258	litres
Fuel Economy 1	6.719	litres/100km (from vehicle trip meter)
Fuel Economy 2	6.771	litres/100km (from dash dyno trip meter)

Date:	20/08/2012		
Fuel Type	ZX	**Driver**	Hayden to Putararu/John to Taupo
Vehicle:	Skoda	**Plate No**	GKN 577

Tyre Pressures	Front		Rear	
	L	R	L	R
Start	32	32	30.5	30.5
Finish	32	32	30	30

Vehicle Data

Odometer start:	1518	km
Odometer finish:	1820	km
Trip distance:	301.2	km

DashDyno Data

Average Economy	6.9
Fuel Used	20.6
Average Speed	69.9
Distance Travelled	299.9
Drive Time	4.18
Idle Time	0.24
Idle Time %	9.6

Refuelling

Container Tare weight	1.764	kg
Fuel Density	0.7507	kg/l
Fuel Temperature	13.4 - 13.6	°C

Weighed amounts	1	2	Brim	Brim
	kg	kg	kg	kg
Full weight	15.696		2.116	1.426
Empty weight	3.546		0.29	0.582
Amount	12.15		1.826	0.844
Calculated volume	16.185		2.432	1.124

Total volume	19.741	litres
Fuel Economy 1	6.554	litres/100km (from vehicle trip meter)
Fuel Economy 2	6.583	litres/100km (from dash dyno trip meter)

Date:	22/08/2012		
Fuel Type	U95	**Driver**	Hayden to Hunterville/John to Wellington
Vehicle:	Skoda	**Plate No**	GHP 686

Tyre Pressures	Front		Rear	
	L	R	L	R
Start	32	32	30.5	30.5
Finish	32	32	30	30

Vehicle Data

Odometer start:	2719	km
Odometer finish:	3100	km
Trip distance:	380.5	km

DashDyno Data

Average Economy	6.9
Fuel Used	26.09
Average Speed	65.2
Distance Travelled	380.5
Drive Time	5.49
Idle Time	0.53
Idle Time %	15.4

Refuelling

Container Tare weight	1.804	kg
Fuel Density	0.7424	kg/l
Fuel Temperature	13	°C

Weighed amounts	1	2	Brim	Brim
	kg	kg	kg	kg
Full weight	14.938	12.524	1.248	
Empty weight	2.61	6.902	0.976	
Amount	12.328	5.622	0.272	
Calculated volume	16.606	7.573	0.366	

Total volume	24.545	litres
Fuel Economy 1	6.451	litres/100km (from vehicle trip meter)
Fuel Economy 2	6.451	litres/100km (from dash dyno trip meter)

Date:	22/08/2012		
Fuel Type	ZX	**Driver**	John to Hunterville/Hayden to Wellington
Vehicle:	Skoda	**Plate No**	GKN 577

Tyre Pressures	Front		Rear	
	L	R	L	R
Start	32	32	30.5	30.5
Finish	32	32	30	30

Vehicle Data

Odometer start:	1945	km
Odometer finish:	2324	km
Trip distance:	379.7	km

DashDyno Data

Average Economy	6.8
Fuel Used	25.7
Average Speed	66.6
Distance Travelled	377.3
Drive Time	5.39
Idle Time	0.46
Idle Time %	13.6

Refuelling

Container Tare weight	1.804	kg
Fuel Density	0.7424	kg/l
Fuel Temperature	13	°C

Weighed amounts	1	2	Brim	Brim
	kg	kg	kg	kg
Full weight	15.378	10.864	1.51	
Emprty weight	3.024	5.394	1.3	
Amount	12.354	5.47	0.21	
Calculated volume	16.641	7.368	0.283	

Total volume	24.291	litres
Fuel Economy 1	6.398	litres/100km (from vehicle trip meter)
Fuel Economy 2	6.438	litres/100km (from dash dyno trip meter)