

DEVELOP OF A BI-FUEL VEHICLE: ALTEA XL 1.6 MPI BI-FUEL

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Abstract

In response to an increasing demand for vehicles that run on cheaper alternative fuels, eligible for financial incentives available from local government, SEAT has developed a bi-fuel Altea XL that runs on both petrol and liquid petroleum gas. Greater fuel tank capacity increases vehicle range to over 1200km, whilst location of the gas tank under the rear luggage floor maintains the Altea XL's minimum luggage capacity of 405 litres.

Development and test release of a bi-fuel installation on the basis of the SEAT Altea XL with 1.6 75kW MPI engine and enabling the vehicle to run on either petrol or liquid petroleum gas (LPG).

Both engine and suspension have been modified or adapted to the new gas installation and an optimized gas injection minimizes power loss in LPG mode whilst ensuring full EU4 emissions compliance.

Keywords: Bi-fuel, bi-fuel engine

1. Introduction

To test and technically release a bi-fuel petrol / LPG aftermarket installation, based upon the SEAT Altea XL model with 1.6 75kW MPI engine, thus providing target customers with a bi-fuel vehicle that's commercially available through the SEAT dealer network and maintains the base vehicles after-sales warranty.

To define and implement a small series build process that's both compatible with the base vehicle build and ensures that all LPG installations are built to the same quality standards.

To enable SEAT to respond for the first time to a growing demand for vehicles that are capable of running on alternative fuels, whose benefits of lower running costs together with the availability of government incentives for inner city use make these vehicles an increasingly popular option for large fleet and taxi operators.

2. Description of the developed product

There are some technical characteristics about the vehicle that is going to be modified and the details of the LPG installation and performance of this model.

a) Vehicle characteristics

Model:	SEAT Altea XL
Engine:	1.6l 2v MPI
Gearbox:	5 speed manual
Traction:	Front wheel drive
Maximum Power:	

Petrol mode	75 kW / 5600 rpm
LPG mode	73 kW / 5900 rpm
Maximum Torque:	
Petrol mode	146 Nm / 3800 rpm
LPG mode	137 Nm / 3900 rpm
Emissions EU4	
Fuel consumption combined cycle:	
Petrol mode	7.8 l / 100 km
LPG mode	10.9 l / 100 km
CO2 mixed cycle:	
Petrol mode	189 g / km
LPG mode	172 g / km
Vehicle range:	1230 km (545 km LPG and 685 km petrol)
Luggage capacity:	405 – 925 litres
Kerb weight:	1430 kg
Max. Payload:	549 kg
LPG installation weight:	71 kg
Fuel running costs:	
Petrol mode	0.08 € / km
LPG mode	0.06 € / km

b) LPG installation details

Manufacturer: Motor GLP S.A.U.

Main components:

- 74 litre LPG tank
- LPG filling valve
- Under floor fuel lines
- Gas pressure regulator
- LPG injectors
- LPG wiring harness
- ECU for LPG operation
- LPG switch and level indicator

c) Vehicle performance

Maximum speed

 Petrol mode: 175 km / h

 LPG mode: 172 km / h

Overtaking times

60 – 120 km / h 4th gear

Petrol mode: 18.0 s

LPG mode: 19.1 s

60 – 120 km / h 5th gear

Petrol mode: 25.9 s

LPG mode: 29.4 s

3. Description of the innovations introduced by the project

Aftermarket LPG installations have been available for many years. However, the very nature of adapting universal parts to a specific application has generally resulted in solutions that reduce or impair the original vehicles characteristics and in consequence SEAT has never given its official technical approval to such installations. SEAT's capacity to innovate and to respond to a growing demand by customers for vehicles that can run on alternative fuels has led to the Company to test an innovative product and define a build process that is detailed in this report.

The principal innovations are:

1. *Optimizations of the base vehicle to suit the post build installation.*
 - Modified engine cylinder head and valves to improve LPG endurance performance.
 - Modified rear suspension settings.
 - Removable luggage floor to improve access to cargo area.
 - Tyre-fit set and tool kit under luggage floor.
2. *Fully integrate the aftermarket installation into the base vehicle*
 - Optimise the height of the LPG tank assembly in order to fit neatly below the luggage floor whilst maintaining an LPG tank capacity of 74 litres (60 litres effective volume).
 - Integration of the LPG fuel filler behind the petrol filler cover.
 - Optimise fuel line and electrical wiring routes to improve durability and quality performance.
 - Integrate gas switch and level indicator into the vehicle dashboard.



Figure 1. Full 405 litre load capacity with removable luggage floor in place



Figure 2. LPG tank and fuel lines housed beneath the luggage floor



Figure 3. Standard fuel tank filler cover



Figure 4. Petrol and LPG fillers located behind the same cover



Figure 5. General view of engine bay with LPG installation



Figure 6. LPG ECU located on left-hand side of engine bay



Figure 7. Tyre-fit set and tool kit located in recess behind LPG tank



Figure 8 Gas switch and level indicator located in general light switch A2 Engine power and torque curves Petrol mode / LPG mode

3. *A small series build process that combines quality control without affecting the standard build process of the base vehicle.*
4. *Definition of a complete test procedure that ensures product compliance not only with ECE R115 homologation standards but also with the kind of strict technical standards that SEAT applies to all of its vehicles including:*
 - Front crash
 - Rear crash
 - Accelerated fatigue testing
 - Individual component testing
 - Climate chamber tests
 - Performance and fuel consumption
 - Emissions control testing
 - Engine test bed endurance
 - Road endurance testing
 - In-service validation with target users

The appliance of such stringent technical controls enables the Company to offer the bi-fuel installation directly through its appointed dealer network and offers customers the benefit of an after-sales warranty. Taxi operators can order the specific factory-assembled taxi option together with a bi-fuel installation.

3.1. Optimisations of the base vehicle to suit post build installation

One of the main project goals has been to avoid any interruptions in the main vehicle assembly process. This way SEAT avoids introducing costly low volume modifications in the factory and ensures that vehicle build remains as flexible as possible, allowing clients to purchase the bi-fuel option with any combination of factory-fitted options and thus tailoring the vehicle to their needs. All specific LPG modifications to the base vehicle are made in a separate assembly hall, together with the LPG installation.

In order to ensure long term durability of the base 1.6 MPI engine in LPG operation, SEAT's engine development department has introduced important improvements to the cylinder head and exhaust valves. Based on VW Group's long experience in the manufacture of gas technology engines, the improvements ensure that critical high mileage clients such as taxi operators can operate almost always in cost effective LPG mode.

The fully fuelled LPG tank installation under the rear luggage compartment means an additional weight of some 50kg over the rear axle. To compensate this, the rear suspension settings have been upgraded. These changes ensure both ride and handling remain as good as the base vehicle and that ride height complies with the manufacturers original specifications.

One of the major drawbacks with bi-fuel aftermarket installations is the important loss in available luggage space and the unsightly appearance of an additional fuel tank when opening the rear hatch. This innovative project has overcome both problems by ensuring that the entire installation lies neatly out of sight beneath the factory-fitted removable luggage floor. The Altea XL already offers best in class luggage accommodation and this installation allows for a minimum luggage capacity of 405 litres. With both rear seats folded, the capacity can be increased to 925 litres without impairing rear visibility.

With the LPG tank occupying the spare wheel recess, the bi-fuel option comes as standard with a factory-fitted tyre-fit set and tool bag. Both elements are located in a polystyrene tray located behind the LPG tank.

3.2. Integration of the aftermarket installation

Throughout the development programme, modifications have been made to the LPG installation that ensures its full integration into the base vehicle.

An LPG tank capacity of 74 litres (60 litres effective volume) is best in class for this category of vehicle and helps ensure that users have an acceptable range in those markets where the LPG distribution network is still not as widespread as possible. This has meant the need to contain the overall height of the tank assembly and the fixing points have been developed accordingly. The result is a vehicle range of 545 kilometres on LPG.

The LPG fuel filler has been integrated behind the original petrol filler flap. This avoids unnecessary holes in the vehicle bodywork and simplifies the refuelling process.

The gas injectors have been improved to ensure strict compliance with EU4 emissions standards and ECU software definition has been upgraded to suit.

Fuel lines and wiring routes have been optimised in order to avoid thermal damage and premature wear. Electrical connections have been redesigned and improved to ensure that all post assembly operations comply with SEAT quality standards.

The gas switch and gas level indicator has been relocated to improve visibility during operation.

3.3. Small series build process

The project has been conceived as a product built in small series volume that responds to a niche market demand. The need to combine limited production volumes with rigorous quality control of the post build process has led the project group to centre its efforts on a process that combines the following parameters:

- Standard build options mounted in factory
- No special requirements mounted in the factory
- Centralised post build workshop
- All production built according to a technically released reference vehicle
- Distribution of the finished product via established routes to authorised dealers
- Limited production levels

The base vehicle is the current Altea XL 5 door hatch with a standard 1.6l MPI petrol engine. The vehicle can be built with all currently available factory fitted options although the post build installation makes the addition of the removable luggage floor and tyre fit options obligatory equipment. The base vehicle leaves the factory as a standard, commercially available product.

The LPG system supplier, Motor GLP, supplies each complete kit to a central workshop adjacent to the SEAT factory in Martorell.

From the assembly hall, each vehicle passes directly to the central workshop where the complete transformation process takes place. Using a technically released model as patron, the components that make up the installation are each mounted according to specific assembly instructions, ensuring that all models are built to the same standard and layout. Specific parts that require changing, such as engine and suspension components, are

substituted in the central workshop, ensuring that all reworking is carried out according to Company quality standards.

Once complete the finished product is quality checked and tested. Post-build checks are made in both petrol and LPG operation.

Distribution of the final vehicle is made using the established SEAT logistics network and in the case of those vehicles destined for use as taxis, the specific taxi components are installed as with all other SEAT taxis, either by the official dealer or by the approved taxi equipment supplier.

This process is limited to an annual production volume of some 1500 - 2000 vehicles.

3.4. Definition of a complete test procedure

In order for SEAT to validate the aftermarket installation, a wide ranging test programme has been defined that ensures a high degree of compliance with SEAT's own internal testing standards.

ECE R115 homologation ensures that all components are individually homologated and that the installation complies with all relevant legal parameters. However, in order for SEAT to give its approval to the installation, the legal requirements have been complemented by additional tests. An extensive test programme has been defined and performed that ensures the following objectives:

- The long term durability of the product
- The safety of the vehicle and its occupants
- SEAT warranty conditions on the base vehicle

For this purpose a small fleet of 4 test vehicles has been built and tested according to a test programme that is still ongoing at the time of writing. Testing began in 2006 and an initial release is scheduled for May 2007. Final durability tests will conclude according to schedule by the end of the second quarter of 2007.

The test programme has been designed to technically release both the Altea XL and Toledo 1.6 MPI models, given the fact that both vehicles are available with the factory fitted taxi option. The LPG installation is identical for both versions.

The final technical sign off of a reference model, which incorporates all necessary modifications, is made before the production process can begin. Once released, this reference vehicle is used as the production standard against which all vehicles are built. Any running changes can only be approved by SEAT if they are first mounted and released in the reference vehicle.

4. Impact of the project on the Company and on the automobile trade

This vehicle is SEAT's first official commercial offer of a bi-fuel vehicle designed to meet the growing demand in Spain and abroad for vehicles powered by alternative fuels. It is a clear example of SEAT's long term commitment to alternative fuels and to providing its customers with products that respond to market demand. As Spain's leading Car Company it's only fitting that SEAT has adopted a solution that best adapts to current local market conditions. The actual network of LPG service stations in Spain is expected to increase significantly in the coming months and years and this product enables SEAT to be at the forefront of this market development, sending a clear message to government, industry and customers alike that SEAT products - well-known for their Mediterranean style and performance – are and

will continue to be among the best in terms of meeting current and future fleet emission levels.

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