

TNO report

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Influence of BP Ultimate on engine cleanliness

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1 Introduction

During early 2005, BP introduced two new fuels in the Netherlands. These new products are called BP Ultimate 98 Unleaded and BP Ultimate Diesel. These fuels were formulated to offer several benefits compared to ordinary fuels, specifically in engine cleanliness.

TNO was asked to evaluate the test results from BP, examine the stated claims and, if proven, to give a specific endorsement of calculated claims of the product(s). In order to understand the performed research and the arising conclusions from it, the next section explains the function of certain key fuel properties

Fuel has to supply the energy required for the movement of a vehicle, through the burning of this fuel in the engine. Beside this primary goal, there are several other characteristics that a fuel has to meet, in order to make the engine as efficient and reliable as possible. For example:

- Octane number, which is a measure of the auto-ignition resistance of petrol, indicates how the fuel/air mixture can ignite in a gasoline engine (as designed by the constructor)
- Volatility, which is a measure of a fuel's ability to evaporate, indicates how efficiently a fuel mixes with the air and burns in the engine
- Cetane number, which is a measure of the ignition quality of diesel fuel, indicates how a fuel ignites. Dependent on engine technology, a higher cetane number could have a positive influence on cold starting or combustion noise.
- Lubrication of specific mechanical parts in the engine is required to prevent vast wear or damage
- Cleaning properties of the fuel are also important to prevent or even remove deposits from the fuel intake and injection system
- The controlling of components, in addition to EN norm requirements), can also have a positive environmental effect. For example, limiting sulphur levels.

To be able to guarantee a certain minimum quality of fuel that has to be reached, the European Commission, vehicle manufacturers and producers of fuel made some agreements on this topic in the past. Several typical elements and characteristics of fuels are regulated in EN norm (EN 228 for gasoline and EN 590 for diesel), from which the octane number is the most common known example, besides the amount of aromatics and sulphur. These regulations are adapted and altered during the years, following the needs of vehicle manufacturers and new advanced technical possibilities of fuel producers.

2 Description of procedure

BP Ultimate fuels are made of high-quality base fuel with the addition of some unique components exclusive to BP. To investigate the effect of BP Ultimate fuels versus ordinary base fuels, BP used a variety of petrol and diesel tests. These tests are summarized below. Both popular road vehicles found in the European vehicle parc and laboratory engines that are widely accepted by the industry as being representative for this kind of evaluation are used in this investigation. The data from this research was made available to TNO for this endorsement. The focus of the endorsement was specifically based on the engine cleaning properties of BP Ultimate 98 unleaded and BP Ultimate Diesel, although the improved ignition quality of BP Ultimate Diesel fuel was also assessed. The relevant data can be split up into four subjects:

- Gasoline road vehicle tests. With this type of test the inlet valve cleanliness is observed by a visual inspection through either the injector or spark plug orifice. The valve condition is reported by merit rating ranging from 1 (heavy deposits) to 10 (clear of deposits). The advantage of this method is that no dismantling of the engine is necessary.
- Gasoline laboratory engine tests. The valve cleanliness is measured by weighing the inlet valves of the engine, including the deposits. The weighing takes place before and after the test, in this way the differences in inlet valve deposits (IVD) can be measured very accurately. The valves have to be removed from the engine, so dismantling is needed for this method.
- Diesel engine tests. In modern diesel engines, the fuel is injected directly into the cylinders and does not pass the inlet valves. Therefore any fuel cleaning effects applies to fuel injectors only. Deposits that are formed on the injectors affect the fuel delivery. Diesel engine cleanliness was measured as injector flow loss. The dirtier the injectors, the greater the flow loss. For this method the injectors are taken out of the engine.
- Diesel cetane number tests. The components used in BP Ultimate Diesel should give the base fuel a higher cetane number. The cetane number itself was determined using industry standard tests.

The BP data consists entirely of observations only, which were extensively statistically analyzed by TNO. Besides a validity check, the aim of the investigation was to search for possible dependencies of one or more of the following parameters. During these tests a variety of parameters have been taken into account:

- Different base fuels (gasoline / diesel)
- Gasoline single-point injection and multi-point injection
- Different emissions class of vehicles (e.g. EURO 3 / EURO 4)
- Variation in engine volumes
- Variation in vehicle class and weight
- Variation in exhaust gas aftertreatment systems
- Different mileages of the vehicles

3 Results & discussion

The data shows that the engine cleaning and improved diesel ignition quality effects are most likely caused by BP Ultimate fuels, and are not a function of the vehicle or other conditional parameters, such as the type of engine or the mileage of the vehicle.

- Gasoline road vehicle tests: The cleaning effect depends on the initial level of inlet valve deposits. The larger the amount of deposits, the higher the clean-up effect will be with use of BP Ultimate 98 Unleaded.
- Gasoline laboratory engine tests: Fuels that meet the BP Ultimate 98 Unleaded specification have less IVD than ordinary base fuels by a factor of at least 38
- Diesel engine tests: The injector deposits measured by flow loss across injectors are reduced by a factor of at least 3.2 with BP Ultimate Diesel fuel.
- Diesel cetane tests: BP Ultimate Diesel has a cetane number that is significantly higher than ordinary diesel base fuels.

All of the above mentioned values were statistically evaluated by TNO and were found to be significant at the 95% confidence level.

In general it can be concluded that use of BP Ultimate fuels does result in less deposits resulting in cleaner engines. In general a cleaner engine can have a better efficiency than an engine with a high amount of deposits inside.

4 Endorsement

Based on extensive statistical analysis of the data presented by BP, TNO endorse the engine cleaning effects of BP Ultimate 98 unleaded and BP Ultimate Diesel, and the improved ignition quality of BP Ultimate Diesel. Because the effects of BP Ultimate are clearly dependent on a defined product quality, BP will confirm to TNO the proper blending of their Ultimate products by proof of instruments' calibration and monitoring the amounts of fuel components to make sure the correct product quality is actually used and delivered to BP filling stations. This controlling procedure consists of periodic reports with the following details:

- Analysis results of the base fuel composition
- Analysis results and purchased amounts of the additional components exclusive to BP Ultimate
- Confirmation of the correct component volumes used to produce BP Ultimate fuels
- Calibration reports of all critical equipment gauges used in the manufacture of BP Ultimate

This data will be objective and provable on the basis of a quality system like ISO9000 or equivalent. In this way TNO will be able to ensure that the correct BP Ultimate product quality is being produced to provide the acknowledged performance claims.

5 Signature

Delft,

TNO Science and Industry

A handwritten signature in black ink that reads "R. van Mieghem". The signature is written in a cursive style with a large initial 'R' and a long horizontal stroke.

R. van Mieghem