

# BLENDING OF ETHANOL IN GASOLINE FOR SPARK IGNITION ENGINES

- Björn Rehnlund, Atrax Energi AB

In Spring 2004 the Swedish Emission Research Program (Emissionsforskningsprogrammet, EMFO) decided to finance a study on blending of ethanol in gasoline for spark ignition engines.

The main reason for blending ethanol with gasoline in Sweden and Europe is to reduce fossil carbon dioxide emissions (and thus the greenhouse effect) from vehicles by using bio-ethanol originating from renewable sources. Presently all gasoline sold in Sweden contain 5 % of ethanol (here and throughout the text such percentages refer to the alcohol content of blends by volume) and the relevant authorities are interested in further increasing the bio-ethanol content in gasoline.

Blending bio fuels with a petroleum-based fuel has furthermore the twin advantages that even relatively small percentage additions will result in a substantial total volume of gasoline substitution, and the present infrastructure for distributing fuels can be used largely unchanged.

The main reason behind the study was to see if the knowledge today concerning ethanol blending in gasoline is sufficient for a “final” judgement concerning maximum allowed blending level as for example stated in the European standard on gasoline, EN 228, and in the European Union Fuel directive or if further R,D&D activities is needed.

Today the maximum level of blending ethanol into gasoline is in both the EN 228 standard and in the directive restricted to 5 %. The restriction is inter alia based on the idea that when ethanol is blended into gasoline the vapour pressure increases and with that the risk of increased evaporative emissions and maybe also tailpipe emissions. Today the gasoline is already RVP adjusted to allow blending of ethanol up to 5 % without exceeding the maximum RVP level. It might be questioned if the cost for such an adjustment is motivated from a health and environmental point of view.

It was decided that the study should focus on a problem inventory, literature and web research, but also should include evaporative measurements.

The purpose of the study was to:

- As far as possible identify if ethanol blending in gasoline over a limit of 5 % up to 10 to 20 % might give raise to problems or if it could be performed without any special restrictions.
- As far as possible describe any problems connected to ethanol blending and at which blending level these problems may occur.

Furthermore it was also meant to investigate if data on ethanol blending generated in the USA could be used for relevant prediction concerning blending of ethanol in European and Swedish gasoline

To be able to do this it was found of great importance to:

- Study available literature, collected knowledge, identified data as well as yet undocumented experience concerning emissions when using ethanol blended gasoline.
- Evaluate the relevance of existing investigations and the data generated in them.
- Assess what (if any) further emission studies are needed to estimate reliably the effects of using ethanol blended gasoline on total emissions, both qualitative and quantitative.
- Measuring evaporative emissions from the combustion of different blends of ethanol and neat gasoline.

Examples of issues studied in the project were inter alia:

- Vehicle performance
- Cold start and driving
- Impact of fuel
- Impact of lube oil
- Impact on services and maintenance
- Compatibility and wear
- Impact of vapour lock
- Impact on vapour pressure
- Impact on emissions (regulated as well as un regulated)
- Emissions from a life cycle perspective

Another aim of the study was to study the impact of using such blends on evaporative emissions by carrying out measurements with different grades of base gasoline and different blending proportions of ethanol.

The results and experience presented in the report originate from Sweden, the USA, Japan, Brazil, China, India, Thailand and Australia. Data collected and evaluated are described and discussed in the report.

The main conclusions of the study are:

- There is intense interest world-wide in using ethanol as an automotive fuel, especially in blending ethanol with gasoline. Blending ethanol in a commonly used fossil fuel is generally seen as an easy way to introduce an alternative such as bio-ethanol without costly changes of the fleet of vehicles on the road.
- Ethanol can easily be blended in gasoline by well known methods. Ethanol has a lower heating value than gasoline, which will reduce the energy content of the fuel. However this can be partly offset by the higher octane value of ethanol.
- The main conclusion from using ethanol-gasoline blends in practice is that blends with up to 15 percent ethanol will not have any significant negative effects on the wear of the engine or vehicle performance.

- No significant difference can be seen in regulated emissions when comparing the use of blended fuel (with up to 10-15% ethanol) to the use of neat gasoline.
- Concerning unregulated emissions views differ. Regarding the emissions of benzene, toluene, ethyl benzene and xylene (BTEX) the main conclusion is that there is a slight decrease when using ethanol blends, while for aldehydes there is a significant increase, especially of acetaldehyde and (to a lesser extent) formaldehyde emissions. However, there is a serious lack of data describing the effects under Swedish conditions.
- There will be a slight increase (~2-3%) in fuel consumption when shifting from neat gasoline to a 10 percent ethanol-gasoline blend, depending on the design of the vehicle. Cold starts, in particular, will affect fuel consumption more when using blended gasoline than when using neat gasoline.
- It is difficult to use data generated in the USA for a prediction of the situation in Sweden and Europe. This because the gasoline specification (quality) differs quite a lot between Europe/Sweden and the USA but also between different states in the USA, depending on somewhat different environmental problems that has to be taken into account.

However, there is still a need to generate data and experience by running tests and analysing the environmental effects of blending ethanol with gasoline.

The lack of data is more marked for blends with high ethanol contents (~20 %). Such blends should be avoided before a thorough analysis has been carried out and more data are available.

In the light of the situation and conditions in Sweden and the other countries belonging to the European Union there are certain barriers to overcome in order to succeed with the intention to increase the content of ethanol in blended gasoline. In addition, given the differences in conditions and regulations between Sweden, other countries belonging to the European Union, and regions where there is long experience of running vehicles on blended fuels, a number of issues have to be addressed before the alcohol content of blends is increased.

A first issue to address is the problem that the RVP increases when ethanol is blended with gasoline since current gasoline standards impose limits on its RVP. Therefore, either there must be an exemption for ethanol blended fuels or the base gasoline RVP must be adjusted. Such adjustments are already made today to the base gasoline used in the 5 % ethanol gasoline blends.

A second issue is concern about the performance and start-ability of vehicles at low temperatures, which commonly occur in wintertime, especially in the northern parts of Sweden.

A third issue is whether blends with 10 to 15 percent ethanol in gasoline will affect human health and the environment (both local and regional).

The work of the study has been carried out by:

- Magnus Henke, AVL MTC AB,
- Mats Wallin, Mawalco AB
- Karl-Erik Egeback, KEE Auto Emission Consultant AB/Luleå Technical University

- Roger Westerholm, Stockholm University
- Björn Rehnlund, Atrax Energi AB

The report:

# BLENDING OF ETHANOL IN GASOLINE FOR SPARK IGNITION ENGINES

## PROBLEM INVENTORY and EVAPORATIVE MEASUREMENTS

includes 168 references.