Annex 44: Research on Unregulated Pollutant Emissions of Vehicles Fuelled with Alcohol Alternative Fuels

Project Duration	July 2012–June 2016 (4 years)
Participants **Task Sharing** **Cost Sharing**	 Canada, China, Finland, Israel, Sweden China, Finland, Sweden
Total Budget	€80,000 ($103,000 US)
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Purpose, Objectives, and Key Question

Alcohol fuels have the advantage of a wide range of sources. These fuels can be manufactured from biomass raw materials, agricultural raw materials (e.g., sugar cane, cereals, and rice), timber and urban waste, and fossil fuels (e.g., natural gas, petrochemical, and coal). A number of countries support the use of alcohol alternative fuels. The United States, Brazil, and Sweden encourage the use of ethanol fuel made from biomass materials. Several regions in China, including Shanxi Province and the City of Shanghai, have initiated a pilot program to promote the use of methanol fuel.

However, the use of alcohol fuels blended with gasoline in vehicles may result in the emission of more unregulated pollutants, such as polycyclic aromatic hydrocarbons, aldehydes, and ketones. These substances have very strong stimulation and sensitization. They also have potential genetic toxicity and carcinogenic activity, which could significantly impact human health. This issue is an important factor that could hinder further development of alcohol alternative fuels. Thus unregulated pollutant emissions from vehicles fuelled with alcohol alternative fuels require investigation. This type of research promotes the application of alcohol alternative fuels in a more expedient manner. Measuring the unregulated pollutant emissions of vehicles fuelled with alcohol fuels facilitated achieving the primary objectives of this project — to obtain the unregulated pollutant emission levels of alcohol-fuelled vehicles and to gradually establish the measurement methods and limits of unregulated pollutant emissions. Our research also examined the influences that measurement methods, automotive technology, fuel alcohol content, ambient temperature, test cycles, and other relevant factors have on vehicle unregulated pollutant emissions.

Activities

China carried out the obligations of the Operating Agent during this Annex. As a task-sharing participant, China conducted emissions tests on the chassis dynamometer by using port fuel injection (PFI) and gasoline direct injection (GDI) light-duty vehicles fuelled with gasoline, E10, E20, M15, and M30. The driving cycles were New European Driving Cycle (NEDC) and Federal Test Procedure (FTP)75.

Finland measured two vehicles with three different fuels (E10, E85, and E100). Measurements were made in ambient temperatures of +23°C and −7°C.

Canada provided chassis dynamometer emissions measurements from PFI and GDI vehicles operating on E0, E10, and E20 at 25°C, −7°C, and −18°C using the FTP 75 cycle.

Israel conducted a test program where M15, E10, and normal 95 octane gasoline fuels were used in four different car models. Two driving cycles were used: NEDC and the U.S. Environmental Protection Agency's US06.

Sweden conducted a literature review regarding low blending of alcohol fuels in passenger cars. The review included both regulated and unregulated emissions as well as other experiences related to the use of alcohol fuels. Fourier transform infrared radiation (FTIR), high-performance liquid chromatography (HPLC), and gas chromatography-mass spectrometry (GC-MS) were utilized to synchronously measure regulated and unregulated pollutant emissions from the vehicles in different participant countries.

Key Findings

Key findings from the project can be summarized as follows:

- The transient unregulated emissions, such as formaldehyde, acetaldehyde, toluene, propylene, and 1,3-butadiene, had the highest peak during the first acceleration condition. Then with the catalyst lights off, the emissions values gradually decreased to nearly zero and remained there until the end of the driving cycle.
- Using low-content alcohol fuels (M15 and E10) did not have statistically significant effects on carbonyl emissions. For unregulated emissions of middle-content (M30 and E20) alcohol fuels, unburned methanol or ethanol, formaldehyde, and acetaldehyde increased proportionally (not more than 2 times). BTEX (benzene, toluene, ethylbenzene, and xylene), propylene, 1,3-butadiene, and isobutene

decreased slightly compared to those emissions from gasoline vehicles. For high-content (E85) alcohol fuels, formaldehyde and acetaldehyde were 3 and 9 times higher, respectively, with the use of E85 compared to E0, and BTEX emission rates were approximately 70% to 84% lower with the use of the E85 fuel compared to E0 at 22°C.

- The effect of test temperature was evident for most emissions. The regulated and unregulated emissions in the low ambient temperature were significantly higher than those in the normal ambient temperature. Acetaldehyde was roughly 2 orders of magnitude higher on E85 than on E0 at −18°C. Reductions in BTEX by approximately 50% were also observed at −7°C, and, to a lesser extent, at −18°C, due to the use of the E85 fuel.
- The difference in hydrocarbon emissions in the entire process of the evaporative emission tests of E10, gasoline, and M15 fuels was slight. Although there was a difference in unregulated emissions in the diurnal test of the three fuels, the difference was very small.
- The average unregulated emissions levels of GDI and PFI test vehicles were in the same order of magnitude. Although there were differences in the average emission levels from the same light-duty vehicle during different driving cycles, the largest variation was not more than 2 times. In contrast to nitrogen oxides (NO_x) emissions, the average levels of aromatic hydrocarbons, aldehydes, ketones, and olefins emissions had the same tendency.

Main Conclusions

When the alcohol content in fuels is increased, formaldehyde and acetaldehyde emissions increase, while BTEX, olefins, particulate matter (PM) and particle number (PN) decrease proportionally. The three-way catalyst had a great ability to reduce the carbonyls, aromatic hydrocarbons, and olefins, when it lights off. The effect of test temperature was evident for most emissions. The regulated and unregulated emissions in the low ambient temperature were significantly higher than those in the normal ambient temperature. In contrast to NO_x emissions, the average levels of aromatic hydrocarbons, aldehydes, ketones, and olefins emissions during different driving cycles had the same tendency.

Publications

The Final Report Draft was submitted in April 2016.