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Fuel economy and emissions evaluation of BMW Hydrogen 7 Mono-Fuel demonstration vehicles

Thomas Wallner[a], Hennning Lohse-Busch[a], Stephen Gurski[a], Mike Duoba[a], Wolfgang Thiel[b], Dieter Martin[b], Thomas Korn[c]

[a] Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439, USA

[b] BMW Group, 80788 Munich, Germany

[c] BMW Group, 5900 Arcturus Avenue, Oxnard, CA 93033, USA

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Abstract

This article summarizes the testing of two BMW Hydrogen 7 Mono-Fuel demonstration vehicles at Argonne National Laboratory's Advanced Powertrain Research Facility (APRF). The BMW Hydrogen 7 Mono-Fuel demonstration vehicles are derived from the BMW Hydrogen 7 bi-fuel vehicles and based on a BMW 760iL. The mono-fuel as well as the bi-fuel vehicle(s) is equipped with cryogenic hydrogen on-board storage and a gaseous hydrogen port fuel injection system.

The BMW Hydrogen 7 Mono-Fuel demonstration vehicles were tested for fuel economy as well as emissions on the Federal Test Procedure FTP-75 cold-start test as well as the highway test. The results show that these vehicles achieve emissions levels that are only a fraction of the Super Ultra Low Emissions Vehicle (SULEV) standard for nitric oxide (NO_x) and carbon monoxide (CO) emissions. For non-methane hydrocarbon (NMHC) emissions the cycle-averaged emissions are actually 0 g/mile, which require the car to actively reduce emissions compared to the ambient concentration. The fuel economy numbers on the FTP-75 test were 3.7 kg of hydrogen per 100 km, which, on an energy basis, is equivalent to a gasoline fuel consumption of 17 miles per gallon (mpg). Fuel economy numbers for the highway cycle were determined to be 2.1 kg of hydrogen per 100 km or 30 miles per gallon of gasoline equivalent (GGE).

In addition to cycle-averaged emissions and fuel economy numbers, time-resolved (modal) emissions as well as air/fuel ratio data is analyzed to further investigate the root causes of the remaining emissions traces. The BMW Hydrogen 7 vehicles employ a switching strategy with lean engine operation at low engine loads and stoichiometric operation at high engine loads that avoids the NO_x emissions critical operating regime with relative air/fuel ratios between $1 < \lambda < 2$.

The switching between these operating modes was found to be a major source of the remaining NO_x emissions.

The emissions results collected during this period lead to the conclusion that the BMW Hydrogen 7 Mono-Fuel demonstration vehicles are likely the cleanest combustion engine vehicles ever tested at Argonne's APRF.

Keywords: BMW Hydrogen 7; Efficiency; Emissions

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