Light/Medium-Duty Fleet Applications

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Abstract

NRG Tech has developed and implemented a retrofit strategy for light and medium-duty vehicles to convert them to operate on mixtures of hydrogen and natural gas (called HCNG). The vehicles achieve equal vehicle range and reduced exhaust emissions, and are more powerful than the same vehicle operating on natural gas alone. The retrofit strategy uses mixtures of hydrogen and natural gas containing at least 30 mole % hydrogen, incorporates exhaust gas recirculation for charge dilution, utilizes three-way catalyst for emissions control, and includes a supercharger for superior performance. One light-duty and one medium-duty vehicle are being retrofitted. The light-duty vehicle is a Ford F-150 dedicated natural gas truck, and the medium-duty vehicle is a 23-passenger ElDorado paratransit bus. The bus has been in service as a natural gas retrofit. Preliminary testing has shown equivalent vehicle range (about 200 miles), reduced NOx and CO emissions, and a 28% increase in horsepower for the OEM Ford F-150. Conversion of the ElDorado bus is expected to be completed before the end of this fiscal year.

Introduction

The project is designed to bring hydrogen fuels to the marketplace in the short term. Because of the current high cost of hydrogen and the high purity hydrogen requirements of current fuel cell technology, the successful commercial implementation of hydrogen as a fuel is very much in the future. Because of this situation, a strategy is needed for earlier commercial implementation of hydrogen as a fuel. That strategy is to supplement natural gas with hydrogen for use in internal combustion engines. The rate of supplementation ranges between 30 and 50% by volume hydrogen. This range allows for enough hydrogen to significantly enhance the combustion of natural gas while remaining within an operational window that does not require extensive engine modifications.

Goals and Objectives

The goals and objectives for the project are:

- To exceed California 2002 SULEV emissions
- To enhance vehicle performance
- To develop a commercialization strategy for economic growth for the state of Nevada

NRG Tech has developed and implemented a retrofit strategy for light and medium-duty vehicles to convert them to operate on mixtures of hydrogen and natural gas. The vehicles achieve equal vehicle range and reduced exhaust emissions, and are more powerful than the same vehicle operating on natural gas alone. The retrofit strategy uses mixtures of hydrogen and natural gas containing at least 30 mole % hydrogen, incorporates exhaust gas recirculation (EGR) for charge dilution, utilizes three-way catalyst for emissions control, and includes a supercharger for superior performance. One light-duty and one medium-duty vehicle are being retrofitted. The light-duty vehicle is a Ford F-150 dedicated natural gas truck, and the medium-duty vehicle is a 23 passenger ElDorado paratransit bus. The bus has been in service as a natural gas retrofit.

Our project partners are the City of Las Vegas, who will refuel the vehicles; Bechtel Nevada, who is the project manager; and the Regional Transit Commission, who will operate the paratransit bus.

Retrofit Strategy

The retrofit strategy uses mixtures of hydrogen and natural gas containing at least 30 mole % hydrogen, incorporates exhaust gas recirculation (EGR) for charge dilution, utilizes three-way catalyst for emissions control, and includes a supercharger for superior performance. This deviates from our original strategy of using lean burn as the charge dilution mechanism. The reasons for this change are as follows:

- Improved Power

  Lean burn created a problem with acceleration from a complete stop. Once the supercharger created boost, the driveability was excellent. However, off-idle acceleration was poor. The solution to this problem was to change the stall characteristics (the “K” factor) of the torque converter. This is a labor and capital expense burden. Also, because the amount of EGR can be varied without proportionally affecting the vehicle-out NOx emissions, the supercharger can be designed to improve vehicle performance superior to that achieved by the same

vehicle operating on gasoline.

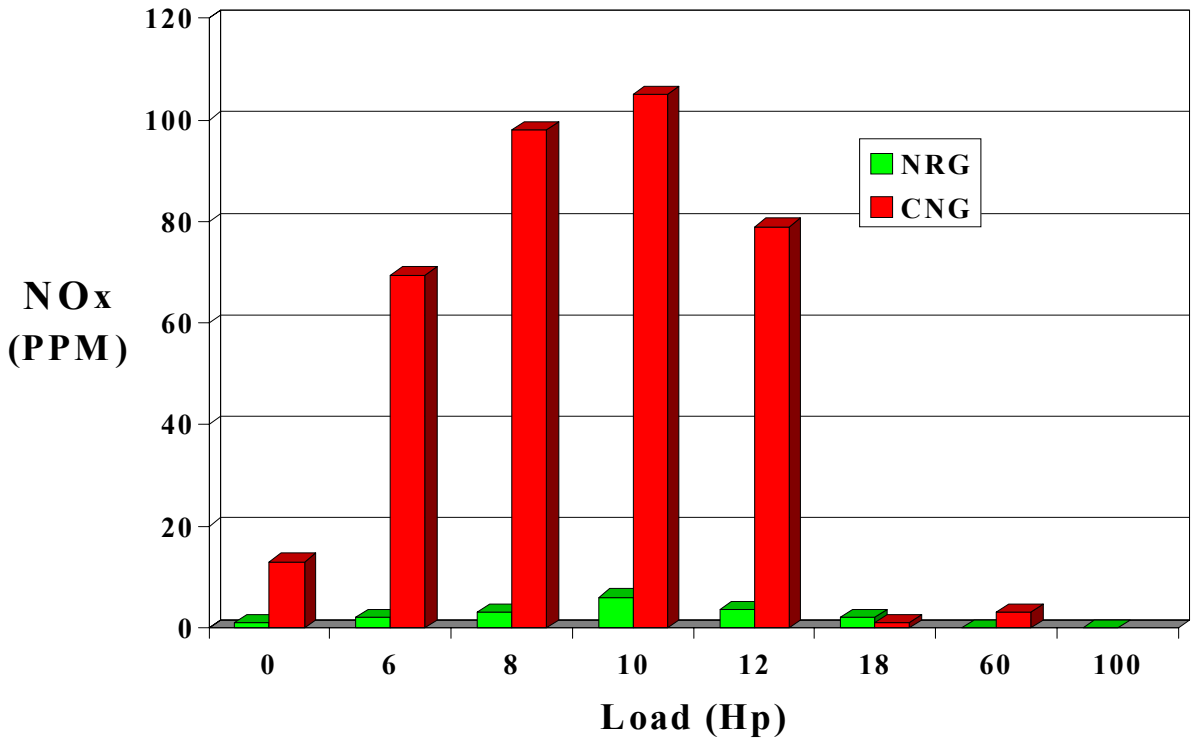
- Uses Existing Engine Computer
  With the lean burn strategy, an aftermarket engine control computer was required to control air-fuel ratio and ignition timing. By using NRG's EGR strategy, the factory computer is retained.
- Uses Existing Oxygen Sensor
  For lean burn, a special oxygen sensor, called a UEGO sensor, had to be incorporated to control air-fuel ratio with 10% exhaust gas oxygen. These sensors and associated electronics are very expensive and prone to failure. With the EGR system, the standard oxygen sensors are used.
- Uses Existing Feedback Control System
  For a three-way catalyst system to operate at maximum efficiency, a very precise, complex feedback control strategy must be used. By using EGR charge dilution, the factory oxygen control strategy is applicable to HCNG fuel.

The bottom line to these advantages is that the current retrofit using HCNG with EGR for charge dilution become a much more cost-effective retrofit.

Current Results

Figure 1 shows the NOx emissions results for chassis dynamometer testing of the Ford F-150. Of note is the ambient temperature and vehicle testing methodology for these results. Dynamometer cell temperature for these tests was approximately 42°F and air was forced underneath the vehicle chassis to simulate actual driving conditions in a cold climate.

Figure 1. Ford F150 NOx Emissions - CNG Vs. NRG HCNG Technology



Notice that the NOx emissions results are very dependent upon catalyst temperature for natural gas operation. By reducing engine out NOx emissions by a factor of from nine to four, the catalyst system using HCNG and NRG's implementation technology does not have to produce high effectiveness to eliminate NOx emissions. Once the catalyst comes up to temperature at higher loads, the factory natural gas system will perform effectively.

Preliminary testing has also shown equivalent vehicle range (about 200 miles for the F-150), reduced NOx and CO emissions, and a 28% increase in horsepower for the OEM Ford F-150.

Conclusions

NRG Tech has developed a low-cost retrofit package for light-to-medium duty vehicles that will incorporate up to 50% hydrogen in the fuel. This package will improve performance and exhaust emissions over the unconverted vehicle at a cost that can make it marketable in the current business climate.