A Report on the Emission Performance of the Ford Stratified Charge Engine Using the 1975 Test Procedure

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John C. Thomson
Office of Air Programs
ENVIRONMENTAL PROTECTION AGENCY

Vehicle Tested

The vehicle tested during this evaluation was an Army M-151 1/4 ton truck. This was the same vehicle tested in May 1970 and April 1971, with only minor modifications to the emission control system. The M-151 is a general purpose vehicle used throughout the world by the U.S. Army. It is equipped with a four wheel drive system with the front wheel drive portion controlled by the driver. It is also equipped with a four speed transmission. This transmission has a very low first gear and for normal driving it is not used. For all of the emission tests, the transmission was used only in second, third, and fourth. A modified shift pattern was suggested by Ford due to the unusual weight to horsepower ratio of this vehicle. The Army M-151 was tested with an inertia weight of 2,750 pounds for this series of tests based on shipping weight. This vehicle is supplied with a seventy horsepower engine, and when the friction losses of the drive train are taken into account, can only meet the required accelerations with difficulty. In addition, the independent rear suspension system will not tolerate the vibration from the four cylinder engine at low speed, necessitating more gear changes than normally required. As a result, it is difficult to achieve the best possible emission results from this engine as installed in the Army vehicle.

The engine used in these tests, a 141 CID four cylinder with 3" bore and 3 7/8" stroke, was developed by the Ford Motor Company through joint U.S. Army - EPA funding. This engine is the "low emission" version of their stratified charge combustion system and is called the Proco conversion.

The basic stratified charge system used by Ford uses an unthrottled air intake with fuel injected directly into the cylinder. This engine uses a low pressure (600 p.s.i.) mechanical fuel injection pump that is integrated with the ignition distributor. The injected fuel mixes with a portion of the air in the vicinity of the spark plug, where it is ignited. The combustion system is shown in Figure 1. The extended tip spark plug places the spark near the center of the cup combustion chamber.

In order to provide low emissions from this engine, several modifications were made in the control systems. Extensive dynamometer tests indicated that a very close control over fuel air ratio was required in order to achieve the emission values needed to meet 1976 standards. For this reason an air throttle system was developed to provide a 17:1 air-fuel ratio. In addition exhaust gas recirculation was added to reduce the amount of oxides of nitrogen. Due to the direct cylinder injection this exhaust gas recirculation seems to

have no effect on driveability, even at 11% recycle used during the first three minutes of test. During the remainder of the test, about 9-10% recycle was used.

This engine was provided with a thermal reactor. However, the contribution of the reactor to emission reduction was minimal according to Ford data. In addition, an Engelhard off-the-shelf catalytic reactor was used to reduce the peak on hydrocarbons and to encourage a reaction between the CO and NO in the exhaust. A lead sterile fuel was used to be compatible with this reactor.

The air-fuel ratio control was an experimental unit and did not contain an ambient pressure compensator. The lack of pressure compensation made the system dependent on atmospheric pressure and explains some of the variation in test data. A special spark plug that is similar to a production plug was also used.

As this vehicle does not need enrichment during start or warm-up, there is little change between cold and hot start data other than that found due to the cold catalyst. For this reason repetitive hot start tests were not made.

Data from this vehicle was reported in report number 70-4 "Exhaust Emissions from a Stratified Charge Ford Combustion Process (FCP) Engine". In addition, data on another standard M-151 is in report number 70-2 "Emissions from a Standard M-151 Jeep".

Tests Used

In order to evaluate the emission performance of the vehicles tested, the 1975 LA4-S4 test cycle was used for all tests. This is the test cycle that will be used for certifying all new light duty motor vehicles beginning in 1975. The emission standards for 1975 and 1976 are shown below, with the 1976 standards also shown with the emissions data in Table 1.

	HC	CO	NO_2
1975	0.41	3.4	3.0
1976	0.41	3.4	0.4

Throughout the report, HC will be used to abbreviate unburned hydrocarbons, CO will be used for carbon monoxide and NOx for oxides of nitrogen.

For these tests results are reported with HC measured using a flame ionization detector, CO and CO_2 using a non-dispersive infrared analyzer and oxides of nitrogen using the chemiluminescent technique.

Emission Results

The results of our tests are reported in Table 1. In this table a comparison is made between the projected standards, the vehicle as tested, and the standard M-151. On two new standard M-151's a single number has been obtained by averaging three tests. It appears that the vehicle approaches the standards for 1976. The emission reduction over the standard vehicle is very significant. Emission results using the 1972 test procedure are available in report number 71-23 from the Test and Evaluation Branch.

Conclusions

The Ford stratified charge system has the potential of meeting the 1976 emission standards while still maintaining the driveability and fuel economy of the uncontrolled vehicle.

Table 1

1975 LA4-S4 Emission Test Comparison

All Results in Grams Per Mile

	HC FID	CO IR	NOx CI
PROCO (FCP) Test #1	0.32	0.36	0.56
Test #2	0.34	0.73	0.53
Federal Standards (1976)	0.41	3.4	0.4
Standard M-151 (1 of 2 vehicles, 6 tests)	5.4	122	2.0