An Evaluation of the Questor Emission Control System

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Background

At the request of representatives of the Questor Automotive Products Company a meeting was held at EPA's Ann Arbor laboratory to give Questor the opportunity to describe their "Reverter" emission control system to EPA. Emission data presented at that meeting indicated that the vehicle equipped with the Questor system could achieve the exhaust emission levels required for model year 1976. Durability data was preliminary but encouraging.

To validate the data presented by Questor and to characterize the exhaust emissions during non-LA4 driving modes, EPA testing was scheduled.

Vehicle Tested

The Questor "Reverter" emission control system was installed on a 1971 Pontiac Catalina equipped with a 400 CID V-8 engine, automatic transmission and air conditioning. The emission control system consists of a non-noble reduction catalyst sandwiched between two partial thermal reactors. Carburetor calibration and exhaust port air injection rates are set such that a reducing atmosphere is still present after the exhaust gas passes through the first partial thermal reactor. After the exhaust passes through the NOx catalyst additional air is added to complete the combustion of the HC and CO remaining. Exhaust gas recirculation (EGR) was not used.

The vehicle's exhaust system was constructed from double walled pipe. Air pump discharge is routed to the rear of the vehicle and pumped into the annular cavity surrounding the inner exhaust pipe. The air is then heated by the hot inner pipe as it travels toward the front of the vehicle where it is removed from the annular cavity and injected into the partial thermal reactors at 800°F.

One feature of the Questor system was enleanment of the mixture during high load conditions. When the vehicle is loaded above about 10-15 rear wheel horsepower for a period of time (about 20-40 seconds) a portion of the air injection is switched into the intake manifold. This enleanment does not occur during the LA4 (Federal) driving cycle because the vehicle is not loaded highly enough for a long enough period of time due to the stop and go nature of the cycle. Questor representatives told us the purpose of the enleanment system is to both protect the catalyst from sustained high temperatures and to improve fuel economy during highway operation.

At the time of our testing of the vehicle there was approximately 4,000 miles on the system. Questor representatives are not expecting significant catalyst durability problems. The metallic NOx catalyst is run at very high temperatures (1750°F+) to eliminate lead poisoning. The vehicle had been running on leaded gasoline and leaded gasoline was used during EPA testing.

A schematic of the Questor system appears in Figure 1.

Test Program

Due to other testing commitments the Questor vehicle was only available for one day of testing. More tests are scheduled in the future. The testing performed consisted of one 1975 Federal Test Procedure and a 60 mph steady state cruise. Vehicle fuel consumption was determined using both carbon balance and weighing methods. A description of the Federal Test Procedure is enclosed.

Test Results

Results are summarized in Table I. The gaseous emission levels were below the Federal requirements for 1976. The fuel consumption of 6.9 miles per gallon indicates almost a 25% loss in fuel economy from current production vehicles of similar weight. The exhaust gas was also tested for formaldehyde and only trace levels less than .005 gpm were found.

The emission levels measured at 60 mph were determined after the vehicle had been at 60 mph long enough to activate the enleanment system. Good HC and CO control was maintained although a significant, but not total, loss of NOx control was noticed. (The 3.15 gpm of NOx measured at 60 mph should not be directly compared to the .37 gpm of NOx measured on the Federal (LA4) driving cycle because the engine loading is different.) Fuel consumption during the 60 mph cruise was 15.8 mpg which is comparable to, if not better than, 1972 vehicles of similar weight and size.

Conclusions

1. The Questor emission control system can achieve the 1976 Federal emission levels at low mileage. Durability is yet to be demonstrated.

2. The Questor system causes a considerable (≈25%) loss of fuel economy in stop and go driving.

3. The Questor system does not adversely effect fuel consumption during freeway operation. There is, however, some loss in emission control during freeway operation.

4. There is potential for improving fuel consumption during stop and go driving with further system development.

TABLE I.

Questor Emission Control System

1975 Federal Test Procedure
(all data in grams per mile)

	HC	CO	NOx	MPG
Questor vehicle	.15	2.34	.37	6.9
1975 Federal Standards	.41	3.40	3.1	---
1976 Federal Standards	.41	3.40	.40	---

60 mph Steady State
(all data in grams per mile)

	HC	CO	NOx	MPG
Questor vehicle	.01	10.16	3.15	15.8

FEDERAL EMISSION TESTING PROCEDURES FOR LIGHT DUTY VEHICLES

The Federal procedures for emission testing of light duty vehicles involves operating the vehicle on a chassis dynamometer to simulate a 7.5 mile (1972 procedure) or 11.1 mile (1975 procedure) drive through an urban area. The cycle is primarily made up of stop and go driving and includes some operation at speeds up to 57 mph. The average vehicle speed is approximately 20 mph. Both the 1972 and 1975 procedures capture the emissions generated during a "cold start" (12-hour soak @ 68°F to 86°F before start-up). The 1975 procedure also includes a "hot start" after a ten minute shut-down following the first 7.5 miles of driving.

Vehicle exhaust is drawn through a constant volume sampler (CVS) during the test. The CVS dilutes the vehicle's exhaust to a known constant volume with make up air. A continuous sample of the diluted exhaust is pumped into sample bags during the test.

Analysis of the diluted exhaust collected in the sample bags is used to determine the mass of vehicle emissions per mile of operation (grams per mile). A flame ionization detector (FID) is used to measure unburned hydrocarbon (HC) concentrations. Non-dispersive infrared (NDIR) analyzers are used to measure carbon monoxide (CO) and carbon dioxide (CO_2). A chemiluminescence (CL) analyzer is used to determine oxides of nitrogen (NOx) levels.

These procedures are used for all motor vehicles designed primarily for transportation of property and rated at 6,000 pounds GVW or less, or designed primarily for transportation of persons and having a capacity of twelve persons or less. Each new light duty vehicle sold in the United States in model years 1973 and 1974 must emit no more than 3.4 gpm HC, 39. gpm CO and 3.0 gpm NOx when using the 1972 procedure. In 1975 the standards will change to .41 gpm HC. 3.4 gpm CO and 3.1 gpm NOx using the 1975 procedure. In 1976 the standards will be .41 gpm HC, 3.4 gpm CO and .4 gpm NOx using the 1975 procedure.

QUESTOR EMISSION CONTROL SYSTEM

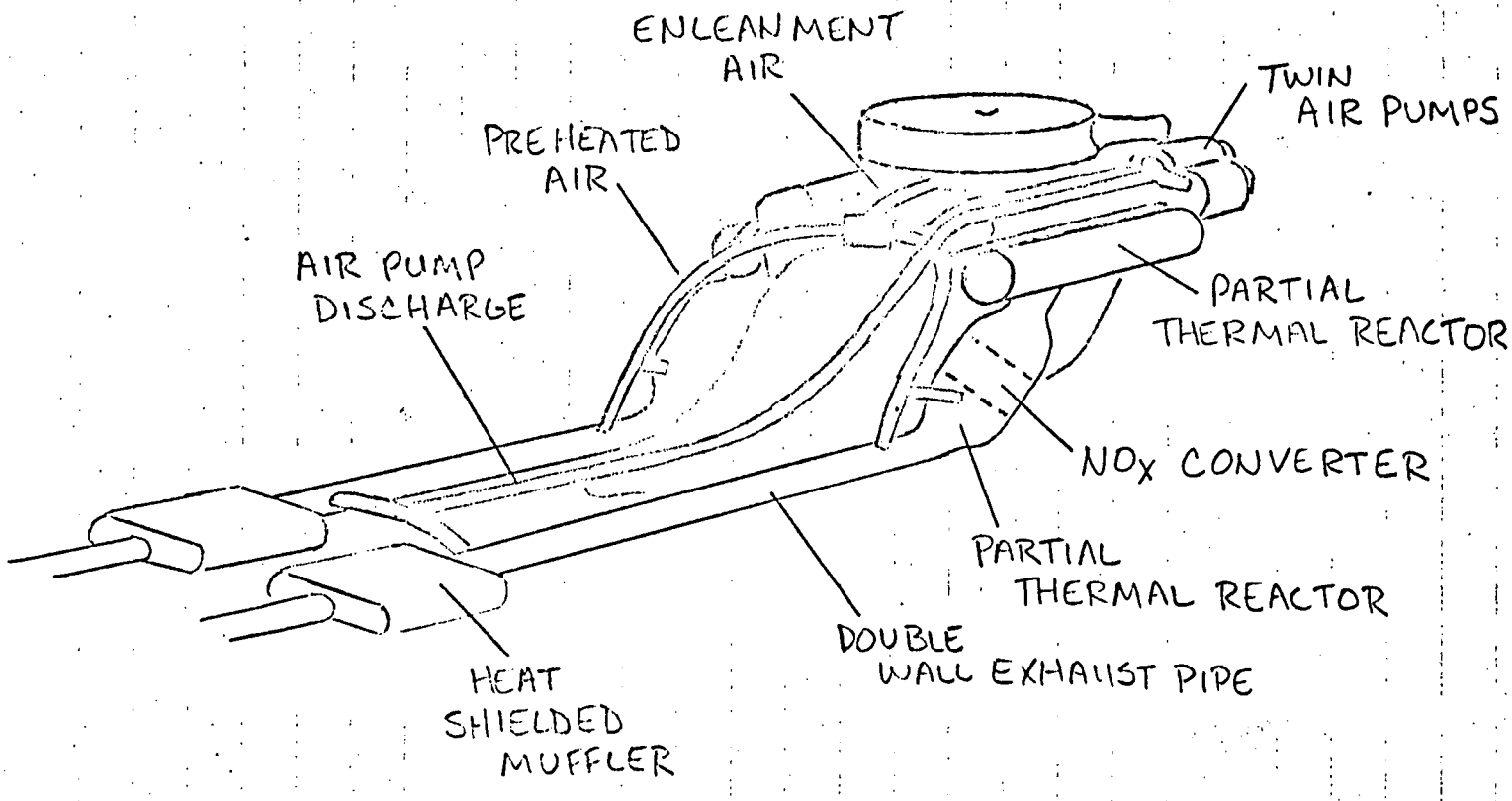

FIGURE 1.