Exhaust Emissions on an Uncontrolled Passenger Car Using Variable Cam Timing

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Device Tested

The exhaust emission characteristics of an uncontrolled car using the Varicam camshaft timing gear were measured to determine the effect of this device on emissions. The test was requested by the U. S. Army Tank-Automotive Command.

To obtain emissions data, a 1962 Chevrolet Biscayne with a 283 cubic inch engine was used both with the Varicam installed and with no device. In order to control temperatures, which may be higher than normal due to lean carburetion and disconnecting the vacuum advance control, a General Motors temperature sensor was installed with the Varicam to allow normal vacuum advance under conditions of high temperature. For full test data the engine was operated using both the stock carburetor and a special lean limit carburetor. This is a carburetor with the leanest air fuel ratio allowed during production. All tests were run using Indolene 30 fuel.

Test Used

The following tests were conducted:

1. Standard 1968 Federal test procedure for exhaust emissions with both cold and hot start (FTP hot or cold).

2. A closed, constant volume sampling technique using nine (9) repeats of the Federal emissions test cycle (9-CVS).

Emission values were obtained both on a concentration basis and on a mass basis.

Closed cycle data was taken using a constant volume sampling technique. The 9 CVS technique is similar to the 1972 procedure; using the 1970 driving schedule instead of the cycle prescribed in the July 15, 1970, Federal Register. The bag samples were analyzed using non-dispersive infrared analyzers for carbon monoxide, flame ionization detector for unburned hydrocarbons and an electro-chemical technique for oxides of nitrogen.

Emission Results

The data shown in Table 1 compares the device using two (2) different carburetors both with and without the Varicam device. The GM temperature sensor was used on the Varicam tests when the vacuum advance was disconnected. The test run after removal of the Varicam with the same ignition and carburetor settings showed poor driveability. The engine performed well with the Varicam installed even with large ignition changes. Thus the Varicam device, while not showing

any great advance by itself in emissions reduction, allows radical change in timing without adversely affecting driveability. The baseline tests described in Table 1 are tests with the Varicam device removed and under conditions described with each test. The primary claim for this device is for increasing horsepower and the cam timing is set for this effect. The effect of tailoring cam timing for emissions has not been investigated by NAPCA, however contacts with industry with this information are being made.

The data shown in Table 1 shows what may appear to be inconsistent data. For the hot cycle data in the as installed condition, both HC and CO were consistent with prior hot start data before the cam was installed. With the ignition optimized and a small air leak, only the first bag sample was usable due to some unknown leakage problem. Thus the data was reported as 5 CVS, this being the first five (5) cycles of the cold start.

After the lean carburetor was installed with the GM kit and optimized ignition advance, both the CVS and FTP hydrocarbon levels went up. Both CO readings went down and NO_x was about the same. When the Varicam was removed, the hydrocarbon level on the FTP did not increase although the CVS number was higher. This is caused by the increase in air flow due to the inability of the engine to run smoothly on the same settings that were possible with the Varicam.

When the engine was returned to manufacturer's specification for baseline measurements, the CO and HC increased to the level experienced prior to the Varicam evaluation. When the lean carburetor was installed, both the HC and CO went down considerably from the stock carburetor levels. The correlation between the FTP and CVS shows changes which would indicate that the lean carburetor air flow was similar to the air flow found with Varicam.

Conclusions

1. The use of the Varicam allowed ignition changes without adversely affecting driveability.

2. The Varicam could be optimized for moderately low emissions.

3. It appears that cam timing may have some effect on emissions and further investigations are warranted.

TABLE 1

Varicam - Stock carb., as installed hot cycle FTP

HC = 469 ppm CO = 1.54%

Varicam - Stock carb., ignition optimized, intake leak

FTP Cold	5 CVS Cold
HC = 136 ppm	HC = 4.8 gpm
CO = 2.7%	CO = 76 gpm
	NO_x = 1.5 gpm

Varicam - Lean carb., GM kit, cold start, ignition advance

FTP	9 CVS
HC = 190 ppm	HC = 5.5 gpm
CO = 1.3%	CO = 61 gpm
NO_x = 620 ppm	NO_x = 1.7 gpm

Baseline - Lean carb., GM kit, ignition advance, poor driveability

FTP	9 CVS
HC = 210 ppm	HC = 6.4 gpm
CO = 2.3%	CO = 61 gpm
	NO_x = 1.7 gpm

Baseline - Manufacturer's specification, Stock carb.

FTP	9 CVS
HC = 800 ppm	HC = 12.9 gpm
CO = 3.6%	CO = 123 gpm
NO_x = 408 ppm	NO_x = 3.2 gpm

Baseline - Manufacturer's specification, Lean carb.

FTP	9 CVS
HC = 508 ppm	HC = 7.3 gpm
CO = 1.9%	CO = 46 gpm
NO_x = 866 ppm	NO_x = 2.5 gpm