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EMISSIONS AND FUEL ECONOMY OF THE AUTOMOTIVE CYLINDER DEACTIVATOR SYSTEM (ACDS)

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Background

The Environmental Protection Agency receives information about many systems which appear to offer potential for emission reduction or fuel economy improvement compared to conventional engines and vehicles. EPA's Emission Control Technology Division is interested in evaluating all such systems, because of the obvious benefits to the Nation from the identification of systems that can reduce emissions, improve fuel economy, or both. EPA invites developers of such systems to provide complete technical data on the system's principle of operation, together with available test data on the system. In those cases for which review by EPA technical staff suggests that the data available shows promise, confirmatory tests are run at the EPA Motor Vehicle Emission Laboratory at Ann Arbor, Michigan. The results of all such test projects are set forth in a series of Technology Assessment and Evaluation Reports, of which this report is one.

The deactivation of one or more engine cylinders is a method that has been proposed as offering potential for vehicle fuel economy improvements. At low power output the throttle is nearly closed. This introduces a "throttling loss", which is the energy the engine must expend to draw the fuel-air mixture through the carburetor throttle opening. By operating an engine on a reduced number of cylinders and operating these at high power levels, the throttling losses are appreciably reduced. The operating cylinders are therefore run at a high brake-mean-effective pressure (BMEP) and therefore potentially more efficiently.

EPA received a request from Automotive Cylinder Deactivator System (ACDS) to perform a 511 evaluation of their cylinder deactivator. Section 511 of the Motor Vehicle Information and Cost Savings Act (15 USC 2011) requires EPA to evaluate fuel economy retrofit devices with regard to both emissions and fuel economy, and to publish the results in the Federal Register. Such an evaluation is based upon valid test data submitted by the manufacturer and, if required, EPA testing.

Data submitted by ACDS showed appreciable fuel economy benefits for some vehicles. Therefore EPA conducted a confirmatory test program on three different test vehicles as part of the evaluation. This report details the results of the confirmatory test program. However, this report is not the full detailed evaluation of the device. That evaluation is contained in the "Announcement of Fuel Economy Retrofit Device Evaluation for the Automotive Cylinder Deactivator System (ACDS)".

ACDS is developing both manual and semi-automatic means of cylinder deactivation. EPA agreed to test the vehicles only with one-half the cylinders deactivated throughout the total, device installed, test sequence. This would provide "worst case" emissions data, i.e. if emissions were negatively impacted by the concept, this should be the worst case. Utilization of the worst case would better permit an understanding of the relationship between benefits and penalties attributable to the concept.

EPA has also tested other cylinder deactivation systems. The Eaton system was tested in a demonstration Cadillac provided by Eaton. The results of these tests are reported in TEB report 80-16 "Emissions and Fuel Economy Tests of a vehicle equipped with the Eaton Valve Selector". A prototype Cadillac was tested in a vehicle provided by the Cadillac Motor Division of General Motors. The results of these tests are reported in TEB report 80-14, "Emissions and Fuel Economy of a Cadillac Prototype with Modulated Displacement Engine". Six years ago EPA also tested a vehicle with 4 cylinders deactivated. The results of that test are given in TAEB report 75-11, "Evaluation of the MSU 4 Cylinder Conversion Technique for V-8 Engines."

The conclusions drawn from the EPA evaluation tests are necessarily of limited applicability. A complete evaluation of the effectiveness of an emission control system in achieving performance improvements on the many different types of vehicles that are in actual use requires a much larger sample of test vehicles than is economically feasible in the evaluation test projects conducted by EPA. For promising systems it is necessary that more extensive test programs be carried out.

The conclusions from the EPA evaluation test can be considered to be quantitatively valid only for the specific test cars used; however, it is reasonable to extrapolate the results from the EPA test to other types of vehicles in a directional manner, i.e. to suggest that similar results are likely to be achieved on other types of vehicles.

Summary of Findings

Overall the use of the ACDS to operate an 8 cylinder engine on 4 cylinders caused CO and NOx emissions to increase substantially, moderate fuel economy increases, braking problems, and poor driveability.

HC emissions were relatively unaffected by ACDS 4 cylinder operation for both the FTP and HFET.

Use of ACDS to operate the engines on 4 cylinders caused 100% to 200% increases in FTP CO emissions to levels near or above the 1979 CO emission standard of 15.0 gm/mi. HFET CO emissions were increased to levels 20 to 100 times higher than baseline.

Use of ACDS to operate the engines on 4 cylinders caused FTP NOx emissions to rise to levels twice the 1979 NOx standard of 2.0 gm/mi. HFET NOx emissions were increased 9% to 55% by operation on less cylinders.

The operation of an 8 cylinder vehicle on 4 cylinders through the use of the ACDS hardware did improve vehicle fuel economy 5 to 16% for the FTP and 3 to 20% for the HFET.

The vehicles had poor driveablity when using the ACDS to operate on 4 cylinders.

The use of a higher octane fuel, indolene, had only a minor effect on vehicle emissions or fuel economy in the 4 cylinder mode. Driveability with 4 cylinders, was slightly worse with commercial unleaded.

Vehicle acceleration times were substantially increased when the 8 cylinder vehicles were operated with 4 cylinders using ACDS. Acceleration times were typically double the comparable times for 8 cylinder operation.

The operation of an 8 cylinder vehicle on 4 cylinders caused a serious loss of braking power assist under some driving conditions.

Operation of an 8 cylinder vehicle on 4 cylinders caused a reduction in the air conditioner airflow when accelerating.

No mechanical problems were encountered that were due to the ACDS hardware. However, no assessment of the durability of the ACDS system was made.

ACDS Description

The purpose of the ACDS is to deactivate one half of the engine cylinders. "This is accomplished by releasing the fulcrum point of the rocker arm, thereby allowing the intake and exhaust valves to stay closed on the deactivated cylinders. The kit also provides means for attaching the pushrod to the hydraulic lifter and furnishes a spring which holds the pushrod and lifter assembly up and away from the camshaft while deactivated".*

The cylinders to be deactivated are selected so that every other cylinder in the firing order is deactivated. This leads to the front and rear cylinders in one bank and the two center cylinders on the other bank being selected for deactivation.

This selection of active and deactivated cylinders means that, on typical carburetor induction systems, the 4 active cylinders are fed the fuel-air mixture by one side of the carburetor and the 4 adjustable cylinders by the other side. Therefore when cylinders are deactivated, there is no air flow thru one side of the carburetor. Also, because the exhaust valves are closed on deactivated cylinders, there is no exhaust flow from deactivated cylinders.

The ACDS kit consists of two star clips, a washer, a spring, a pushrod, a wire clip and a rubber cup plug for each of the eight valves (4 intake and 4 exhaust) deactivated. The pushrod is usually identical to the stock pushrod. The wire clip is a slightly thicker and reshaped replacement for the valve lifter wire clip.

Installation of the ACDS requires removal of the intake manifold and valve covers. Ignition wires, hoses, fuel lines, and other engine hardware, as appropriate, must be removed to allow access to the valve lifters and rocker arm assemblies. The lifters are removed and the wire clip is removed. The lifters are re-installed and connected to the ACDS provided pushrod and spring assembly with the ACDS star clip and wire clip.

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*ACDS product literature "Instruction Manual for Installation of Mechanical ACD System on small and big block Chevrolets", a copy of these instructions is given in the Appendix.

The hardware and its typical installation are shown in figures 1 and 2 below.

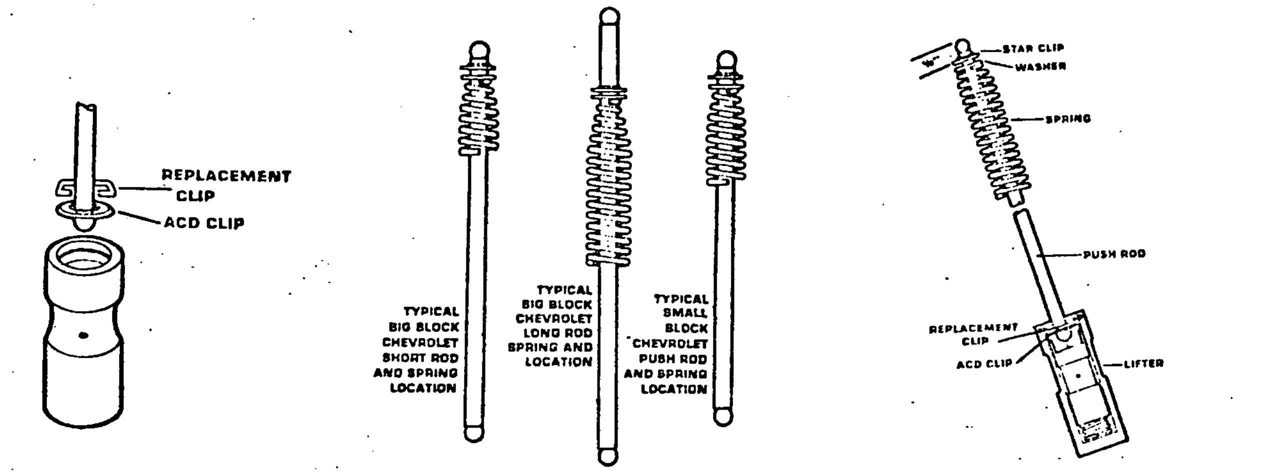

Figure 1
ACDS Hardware

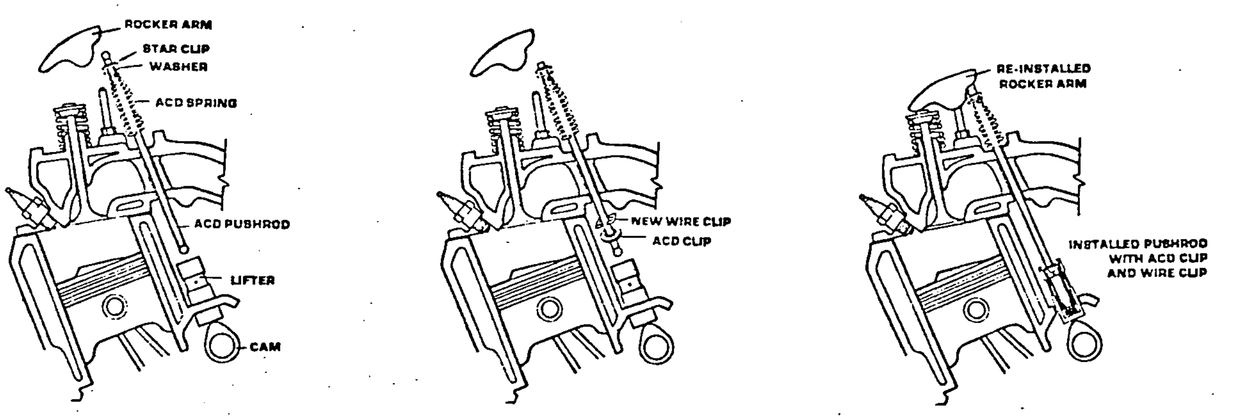

Figure 2
Typical Installation

During installation, 1-1/8 inch holes are drilled in the valve covers. These holes allow a socket wrench access to the rocker arm adjustment nut. This readily permits manual conversion of the engine back and forth between 4 cylinder and 8 cylinder modes. Rubber cup plugs are provided to cap these holes.

No vehicle engine adjustments are required unless specific problems are encountered.

Test Vehicle Description

Two of the test vehicles used in this study were selected on the basis of their being typical full sized, late model vehicles with large displacement V-8 engines. A third vehicle, a Capri, was selected to represent a current vehicle with a relatively larger power to weight ratio. These vehicles were obtained from automobile rental firms.

The three test vehicles used in this study were:

A 1979 Chevrolet Impala equipped with a 5.7 liter V-8 engine, automatic transmission and air conditioning. This vehicle used EGR and an oxidation catalyst for emission control.

A 1979 Mercury Capri equipped with a 5.0 liter V-8 engine, automatic transmission, and air conditioning. This vehicle used an air pump, EGR, and an oxidation catalyst for emission control.

A 1979 Mercury Cougar equipped with a 5.0 liter V-8 engine, automatic transmission and air conditioning. This vehicle used an air pump, EGR, and an oxidation catalyst for emission control.

A complete description of these vehicles is given in the test vehicle description in the Appendix.

Test Vehicle Inspection, Servicing, and Repair

Prior to baseline testing, each vehicle was given a specification check and inspection. The ignition timing, idle speed, and fast idle speed were checked for agreement with the manufacturer's specifications given on the Vehicle Emission Control Information label affixed to the engine compartment and adjusted if required. The vehicles were inspected for engine vacuum leaks, proper connection of vacuum hoses, functioning PCV valve, oil and water levels, and general condition of engine compartment.

The vehicles were also checked with an automotive diagnostic computer. The tests performed were:

(1) Cranking - checks battery, starter draw, cranking speed, dynamic distributor resistance, dwell, and relative cylinder compression.

(2) Alternator - checks alternator power output at 2500 rpm.

(3) Idle - checks rpm, dwell, HC and CO emissions, initial timing, PCV, and manifold vacuum.

(4) Low cruise - checks ignition coil output.

(5) Power balance - checks power output of individual cylinders.

(6) Snap acceleration - checks spark plugs under load.

(7) High cruise - checks ignition dwell, dwell variation, total timing advance.

The Impala and Capri passed the preceding tests. However, the Cougar had insufficient distributor vacuum and mechanical advance. The lack of vacuum advance was corrected by readjusting the vacuum advance control set screw. The lack of sufficient mechanical advance was corrected by grinding off part of the distributor plate to permit additional mechanical advance (it was later determined a part of the distributor plate was installed backwards). After these distributor changes, the Cougar passed the checkout tests.

The above mentioned Ford/Mercury distributor problem has been noted in other Ford vehicles being tested. Apparently the cause of the problem is that part of the distributor plate mechanism can be installed backwards. The unit then functions normally except that it cannot achieve the last few degrees of distributor mechanical advance.

The Impala and Cougar were serviced prior to testing. The air and oil filters were replaced and the engine oil was changed. The Capri had been serviced just prior to delivery and therefore required no servicing.

Test Procedures

Exhaust emission tests were conducted according to the 1977 Federal Test Procedure (FTP) described in the Federal Register of June 28, 1977 and the EPA Highway Fuel Economy Test (HFET) described in the Federal Register of September 10, 1976. The vehicles were not tested for evaporative emissions.

The vehicles were initially tested in the baseline (stock) configuration to determine their emissions and fuel economy performance. The vehicles were then modified by the installation of the ACDS hardware on 4 intake and 4 exhaust valves (ACDS hardware installed on 4 cylinders, no cylinders deactivated). They were then retested in 8 cylinder configuration to insure that emissions and fuel economy had not been changed by the installation process.

The vehicles were then placed in 4 cylinder operation. This was done by backing off the rocker arm fulcrum nut and allowing the ACDS hardware to pull the hydraulic lifter off the cam. The vehicles were tested for emissions and fuel economy with 4 cylinders.

In the 4 cylinder mode, each of the 4 active cylinders would have to work harder than in the 8 cylinder mode. These higher loads would tend to increase the engine's octane requirement. Because the EPA test fuel (indolene) typically has a higher octane rating than commercial fuel, in the 4 cylinder mode the vehicles were tested with both indolene and commercial unleaded.

Additional tests were conducted as an evaluation tool. These consisted of steady state emission tests, acceleration tests, and road evaluations.

EPA supplied all three test vehicles. The Impala and Cougar were modified by ACDS personnel. The Capri was modified by EPA. Each initial conversion took several hours. Most of the installation time was required for removing and replacing engine components and gaskets. EPA did not modify the valve covers but removed them each time a change in the number of active cylinders was required.

Test Results

The objective of this test program was to evaluate the potential fuel economy benefits of an aftermarket cylinder deactivation system and to determine its effects on vehicle emissions. The test results are summarized in the tables and figures in the following paragraphs. More detailed tabulations of the data are given in the Appendix.

1. Federal Test Procedure (FTP) Results

Overall the operation of the vehicles on 4 cylinders caused CO and NOx emissions to increase dramatically. HC emissions were not changed substantially. In 4 cylinder mode, the vehicles failed to meet the 1979 emission standards of 1.5 gm/mi HC, 15 gm/mi CO, and 2.0 gm/mi NOx. Fuel economy increased 5 to 16%. Vehicle driveability was poor in some cases. The results are tabulated in Table I below. All results are the average of two tests unless noted otherwise.

TABLE I
AUTOMOTIVE CYLINDER DEACTIVATION SYSTEM - ACDS
AVERAGE FTP MASS EMISSIONS
grams per mile

TEST CONDITION	HC	CO	CO_2	NOx	MPG
CHEVROLET IMPALA					
8 cylinder baseline	.52	4.03	548	1.50	15.9
8 cylinder w/ACDS(3 tests)	.90	10.13	529	1.54	16.2
4 cylinder w/ACDS	.71	18.77	440	4.06	18.8
4 cylinder w/ACDS commercial unleaded	.79	22.36	440	4.04	18.5

MERCURY CAPRI					
8 cylinder baseline (3 tests)	.78	3.11	507	1.31	17.2
8 cylinder w/ACDS (3 tests)	.84	4.01	503	1.42	17.3
4 cylinder w/ACDS	.68	7.75	459	4.38	18.8
4 cylinder w/ACDS commercial unleaded	.89	16.41	460	4.13	18.1
MERCURY COUGAR					
8 cylinder baseline	.62	3.42	561	2.41	15.6
8 cylinder w/ACDS	.69	4.47	551	2.33	15.8
4 cylinder w/ACDS	.72	11.27	500	4.57	17.0
4 cylinder w/ACDS commercial unleaded	.69	12.44	504	4.86	16.9

FTP BASELINE (Stock) Tests

The purpose of the baseline tests was to insure before testing began, that all of these 1979 vehicles were representative and all of these 1979 vehicles met the 1979 emission standard. The Impala's and Capri's emission levels met the standard and were comparable to the certification tests. (See comparison to the certification vehicles and Table III).

The Cougar's NOx emissions were appreciably above the standard. This information was not available until after the vehicle had been modified. The Cougar's emission control system was functionally checked. A new EGR valve was installed, however the vehicle's emissions remained unchanged. Since several replacement vehicles were unacceptable, and this Cougar was modified, it was tested even though the baseline FTP NOx emissions were above the NOx standard.

In stock configuration, all vehicles had acceptable driveability.

FTP - 8 CYLINDER WITH ACDS MODIFICATION (NONFUNCTIONAL)

The purpose of this series of tests was to establish a reference and to insure that vehicle emissions and fuel economy had not been inadvertently changed because of the disassembly and reassembly operations required for installation of the ACDS hardware. Except for the Impala's CO emissions being doubled, none of the vehicles' emissions or fuel economy had shifted appreciably.

The Impala's CO emissions changed from 4.03 gm/mi to 10.13 gm/mi. The Cougar's CO emissions tended to increase slightly. The exact cause for these changes was not determined. Since the vehicle's emissions were still acceptable (met the standard and similar to the certification levels), testing was continued without additional adjustment of these vehicles. The Capri's and Cougar's emissions and fuel economy were essentially unchanged.

With 8 cylinders operating and ACDS installed, but nonfunctional, driveability remained acceptable.

FTP - 4 CYLINDER WITH ACDS MODIFICATION - INDOLENE FUEL

The vehicles were converted to 4 cylinder operation by deactivating 4 cylinders. This was done by releasing the rocker arm fulcrum nut thus permitting the ACDS hardware to pull the intake and exhaust lifters off the camshaft. As noted before, this caused CO and NOx emission penalties, fuel economy benefits, and driveability problems.

The Impala's HC emissions were decreased 21%. CO emissions doubled to 18.77 gm/mi, a level 25% above the CO emission standard. NOx emissions increased by 160% to 4.06 gm/mi, double the allowable standard. Fuel economy increased 16%. Driveability was acceptable.

The Capri's HC emissions were decreased 19%. CO emissions doubled to 7.75 gm/mi. NOx emissions tripled to 4.38 gm/mi, over double the allowable standard. Fuel economy increased 9%. Driveability was fair. There were numerous transmission shifts. The vehicle had insufficient power to follow the driving schedule during hard acceleration.

The Cougar's HC emissions were not significantly affected. CO emission tripled to 11.27 gm/mi. NOx doubled to 4.57 gm/mi, over double the allowable standard. Fuel economy increased 8%. Driveability was marginal. There were numerous transmission downshifts and upshifts. The vehicle had insufficient power to follow the driving schedule during hard accelerations.

FTP - 4 CYLINDER WITH ACDS MODIFICATION - COMMERCIAL UNLEADED

As previously noted, EPA's indolene unleaded test fuel typically has a higher octane rating than commercial unleaded gasoline. Since the test vehicles would probably be more octane sensitive in 4 cylinder mode than 8 cylinder mode, the 4 cylinder tests were repeated using a commercial unleaded gasoline. The octane ratings of these fuels were:

	Indolene unleaded	Commercial unleaded
Motor Octane Number	88.65	82.57
Research Octane Number	97.45	91.55
$\frac{M+R}{2}$ (combined)	93.05	87.06

The combined number is the value typically posted on the service station pumps.

When tested with commercial unleaded gasoline, all three vehicle's emissions and fuel economy followed trends noted previously for indolene. However, there was additional driveability deterioration, especially detonation. Compared to the 8 cylinder configuration, in 4 cylinder operation, the Impala's HC emissions decreased 13%, but CO emissions further increased to 22.36 gm/mi. NOx emissions were again increased 160% to 4.04 gm/mi. Fuel economy again increased 14%. Driveability was poor. There was considerable hesitation and detonation on accelerations.

Compared to the 8 cylinder configuration, in 4 cylinder operation the Capri's CO emissions, NOx emissions, and fuel economy followed the same trend noted previously for indolene. HC emissions increased 6%, CO emissions increased by a factor of 5 to 16.41 gm/mi, a level that exceeds the CO emission standard. NOx emissions tripled to 4.13 gm/mi, over double the allowable standard. Fuel economy increased 5%. Driveability was fair. There were numerous transmission shifts. The vehicle lacked power for hard accelerations. There was minor detonation on most accelerations.

Compared to the 8 cylinder configuration, in 4 cylinder operations, the Cougar's emissions and fuel economy followed the same trends noted previously for indolene. HC emissions were unchanged. CO emissions tripled to 12.44 gm/mi. NOx doubled to 4.86 gm/mi. Fuel economy increased 7%. Driveability was again marginal. There were numerous transmission downshifts and upshifts. The vehicle had insufficient power to follow the driving schedule during most accelerations. The engine had a tendency to "diesel" when shutoff.

2. <u>Highway Fuel Economy Test (HFET) Results</u>

Overall the operation of the vehicles on 4 cylinders caused CO and NOx emissions to increase substantially. HC emissions were relatively unchanged. Fuel economy increased 3 to 20%. Vehicle driveability was adversely affected in some cases. These results are Tabulated in Table II below. All results are for two tests unless otherwise noted.

TABLE II

Automotive Cylinder Deactivation System - ACDS
Average HFET Mass Emission
grams per mile

TEST CONDITION	HC	CO	CO_2	NOx	MPG
CHEVROLET IMPALA					
8 cylinder baseline	.12	.14	383	1.46	23.1
8 cylinder w/ACDS (3 tests)	.10	.16	375	1.37	23.7
4 cylinder w/ACDS	.20	5.48	303	1.78	28.4
4 cylinder w/ACDS commercial unleaded	.40	16.12	289	1.92	28.1

MERCURY CAPRI					
8 cylinder baseline (3 tests)	.24	.07	374	1.31	23.7
8 cylinder w/ACDS (3 tests)	.22	.11	373	1.37	23.8
4 cylinder w/ACDS	.13	1.47	351	2.12	25.1
4 cylinder w/ACDS commercial unleaded	.13	4.41	353	2.08	24.6
MERCURY COUGAR					
8 cylinder baseline	.17	.31	403	2.54	22.9
8 cylinder w/ACDS	.18	.56	400	2.42	22.1
4 cylinder w/ACDS	.16	4.30	363	2.64	24.0
4 cylinder w/ACDS commercial unleaded	.12	3.33	363	2.67	24.1

HFET BASELINE (STOCK) TESTS

The purpose of these tests was to insure the vehicles' HFET fuel economy were representative. The three vehicles' HFET fuel economy were reasonably comparable to the certification tests. (See comparison to the certification fuel economy vehicles and Table III). The vehicles' emissions and fuel economy were acceptable. Driveability was acceptable.

HFET - 8 CYLINDER WITH ACDS MODIFICATION

The purpose of this group of tests was to establish a reference and to insure the vehicles' emissions and fuel economy had not inadvertently changed during the inital ACDS installation. The emissions and fuel economy of all three vehicles had not significantly changed during modification. Driveability remained acceptable.

HFET - 4 CYLINDER WITH ACDS MODIFICATION - INDOLENE FUEL

The Impala's emissions and fuel economy increased. HC emission doubled to .20 gm/mi. CO increased substantially to 5.48 gm/mi. NOx increased by 30% to 1.78 gm/mi. Fuel economy increased 20% to 28.4 mpg. Driveability was acceptable.

The Capri showed similar emissions and fuel economy trends. HC decreased by one third. CO increased substantially to 1.47 gm/mi. NOx increased by 50% to 2.12 gm/mi. Fuel economy increased 5% to 25.1 mpg. However, the Capri's driveability was fair. There were numerous tranmission shifts and insufficient power to accelerate.

The Cougar also followed these emissions and fuel economy trends. HC remained unchanged. CO increased substantially to 4.30 gm/mi. NOx tended to increase slightly. Fuel economy showed a 9% increase. Driveability was marginal. There was insufficient power for acceleration and the transmission shifted more frequently than normal.

HFET - 4 CYLINDER WITH ACDS MODIFICATION - COMMERCIAL UNLEADED GASOLINE

All three vehicles followed the trends previously noted in 4 cylinder operation. However, as with the FTP, there was again an additional loss in driveability when a commercially available fuel was used.

Compared to the 8 cylinder configuration, the Impala's HC emissions quadrupled. CO emissions rose to 16.12 gm/mi, three times greater than the tests using indolene and 100 times greater than the baseline. NOx emissions increased 40% to 1.92 gm/mi. Fuel economy again increased 19%. Driveability was very marginal. There was hesitation and considerable detonation on acceleration.

Compared to the 8 cylinder configuration the Capri's emissions followed the same trends noted previously for Indolene. HC was decreased one third. CO increased substantially to 4.41 gm/mi. Fuel economy again increased 3% to 24.6 mpg. Driveability was fair. There were numerous transmission shifts and insufficient power to accelerate.

Compared to the 8 cylinder configuration, the Cougar's emissions and fuel economy followed the trends noted for indolene. Namely HC was decreased by one third and there was a substantial increase in CO emissions to 3.33 gm/mi. NOx tended to increase slightly and fuel economy increased 9%. Driveability was again conditionally acceptable.

3. COMPARISON OF TEST VEHICLES TO CERTIFICATION VEHICLES

For comparison, the emission and fuel economy results for comparable 1979 vehicles are given in the tables below. These vehicles had the same displacement engine, same engine emission family, and same inertia test weight as the comparable test vehicle.

TABLE III
1979 CERTIFICATION VEHICLES
Typical FTP Mass Emissions
grams per mile

Vehicle	HC	CO	NOx	Fuel Economy FTP MPG	Fuel Economy HFET MPG
1979 Chevrolet Impala	.57	8.1	1.6	15.0	19.0
1979 Mercury Capri	.63	6.9	1.3	16.7	23.0
1979 Mercury Cougar	.49	6.9	1.7	14.7	20.2

These emission values include the appropriate deterioration factor for each emission family. The most notable deviations of the three test vehicles from the above certification results were:

1) The Capri's and Cougar's FTP CO emissions (stock) were about half the comparable certification value.

2) The Mercury Cougar's FTP NOx emissions (stock) were above the standard and approximately 1.0 gm/mile above its certification levels.

3) All three test vehicles FTP fuel economy (stock) were approximately one mpg higher than the comparable certification vehicle.

4) All three test vehicles HFET fuel economy (stock) were one to two mpg higher than the comparable certification vehicle.

Therefore, except for the Cougar's previously noted high NOx levels, the vehicles were accepted as being representative of their make and model year.

4. COMBINED FUEL ECONOMY

A vehicles' combined Fuel Economy is calculated by using its weighted FTP and HFET fuel economy. The weighting is 55% FTP and 45% HFET. These values are harmonically averaged using the formula:

$$\text{combined fuel economy} = 1/\left(\frac{.55}{\text{FTP}} + \frac{.45}{\text{HFET}}\right) \text{ mpg}$$

The results for these test vehicles are:

Combined Fuel Economy
(indolene test fuel)

	8 cylinder	4 cylinder w/ACDS	percent change
Chevrolet Impala	18.9	22.2	17.4%
Mercury Capri	19.7	21.2	7.8%
Mercury Cougar	18.1	19.6	7.9%

5. STEADY STATE TESTS

The largest net increases and largest percentage increases in fuel economy occurred in the steady state test on all vehicles. HC and CO emissions were relatively unaffected by operation of the vehicles with only 4 active cylinders. The Impala's NOx emissions were also unaffected. However both the Capri and Cougar had large increases in NOx emissions. Best fuel economy for all vehicles was achieved at speeds between 25 and 35 mph. The steady state test results are tabulated in Tables XII, thru XIV in the Appendix. The fuel economy results are also plotted in Figure 3.

The vehicles were also tested for steady state fuel economy on the road tests. The results of these tests are given in Tables XI, XII, and XIII in the Appendix. In general, there was good agreement between the steady state road test and chassis dynamometer test fuel economies. The most noticeable difference was for the Impala at 25 mph. Apparently the vehicle's transmission had not shifted into high gear when tested on the dynamometer.

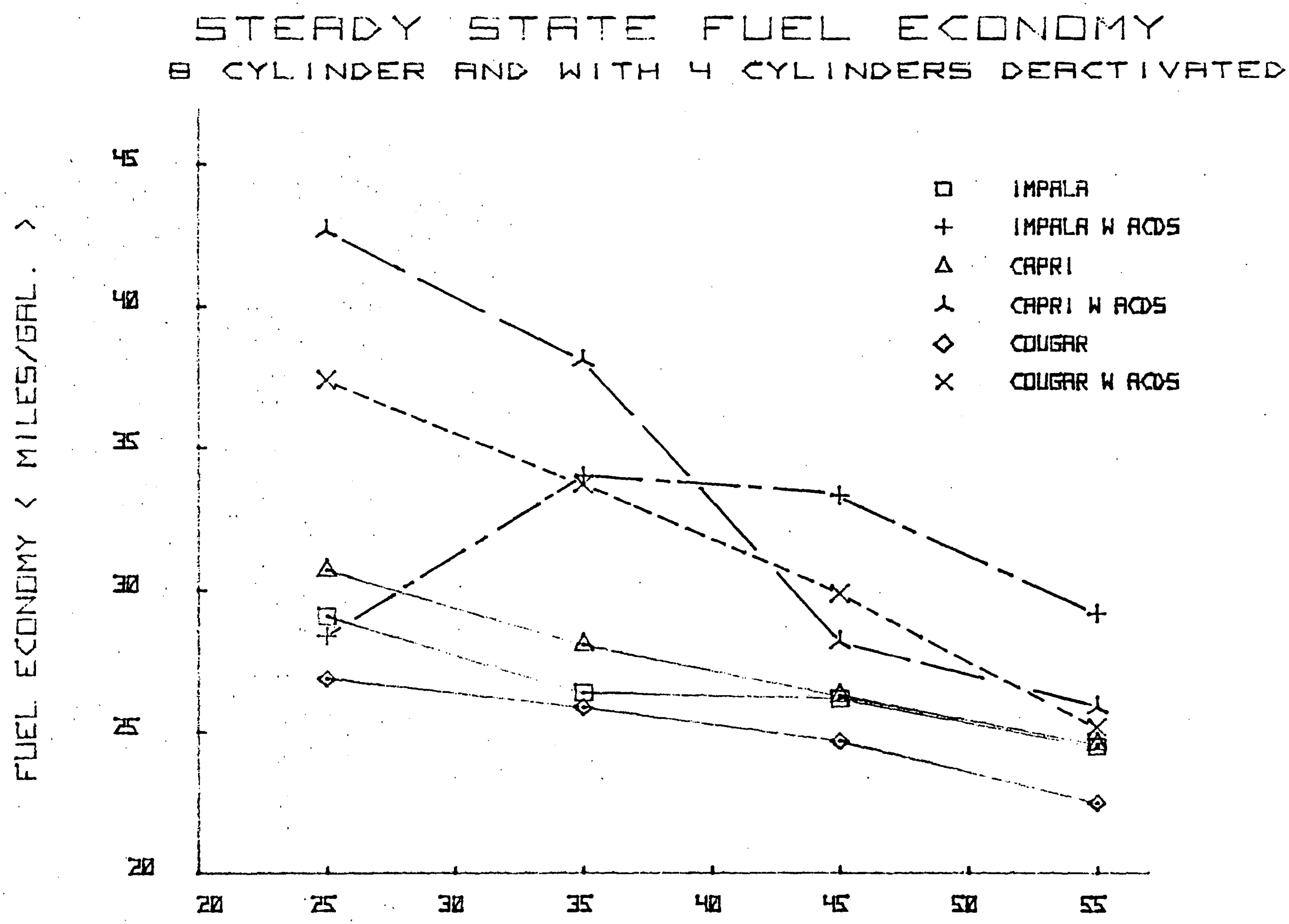

Figure 3 8 cylinder and 4 cylinder (ACDS) fuel economy - dynamometer

6. ACCELERATION TESTS

At the conclusion of the emission tests, acceleration tests were performed on the vehicles using a chassis dynamometer. To minimize tire slippage, the chassis dynamometer's front and rear rolls were coupled together for these tests. The vehicles' speed versus time acceleration characteristics were recorded on a calibrated strip chart recorder. The results are summarized below in Table IVa. Complete results are given in the Appendix.

Table IVa
Average Acceleration Times on the Dynamometer
seconds

1979 Chevrolet Impala

Speed	8 cylinder commercial unleaded	ACDS (4 cylinder) indolene unleaded
0-20	3.1	5.5
0-30	4.5	8.8
0-40	6.1	12.3
0-50	8.3	17.1
0-60	11.2	23.7

1979 Mercury Capri

Speed	8 cylinder commercial unleaded	ACDS (4 cylinder) indolene unleaded
0-20	3.8	6.3
0-30	5.6	9.8
0-40	7.8	14.4
0-50	10.3	21.5
0-60	14.1	29.4

1979 Mercury Cougar

Speed	8 cylinder	ACDS (4 cylinder)	
	indolene unleaded	indolene unleaded	commercial unleaded
0-20	3.0	7.0	6.6
0-30	5.0	11.1	10.8
0-40	7.3	16.1	15.6
0-50	10.0	23.0	22.6
0-60	13.9	--	33.4

During the steady state fuel economy road testing, the vehicles' acceleration capability was also tested. The vehicles' speed versus time characteristics were taken by the use of a stopwatch and the vehicles' speedometer. This was considerably less precise than the preceding dynamometer tests. The test results are summarized in Table IVb on the following page. Complete results are given in the Appendix.

Table IVb
AVERAGE ACCELERATION TIMES ON THE ROAD
seconds

1979 Chevrolet Impala — Not Tested

1979 Mercury Capri

Speed	8 cylinder	ACDS (4 cylinder) indolene unleaded
0-20	Not	6.2
0-30	Tested	9.9
0-40		13.8
0-50		20.7

1979 Mercury Cougar

Speed	8 cylinder	ACDS (4 cylinder)
0-20	--	7.2
0-30	4.8	11.4
0-40	7.2	16.5
0-50	9.5	23.7

Acceleration times were substantially increased by operation of the engine on only 4 cylinders. Acceleration times were only slightly affected by the type of fuel used. Acceleration times for the dynamometer and road tests were similar.

7. SAFETY

During the road tests, braking problems were encountered with the Impala. At times there was no braking power assist when the vehicle was operated with 4 cylinders deactivated. The source of this problem was the low manifold vacuum available during most of the operation on 4 cylinders. Therefore a repeated series of accelerations and braking could reduce the power brake's vacuum reservoir vacuum to levels that are unable to provide power brake assist. This could readily occur in heavy slow speed traffic or when highway cruising is followed immediately by a series of brake applications. This problem was further aggravated when the air conditioning was on, since the air conditioner caused the loss of an additional 2-4 inches of vacuum.

A braking problem was not encountered with the other two vehicles. However, they were not driven in similar heavy traffic conditions and it is, therefore, not known if they too are susceptible to this braking problem.

8. OTHER

When accelerating with only 4 cylinders operating, the Impala's engine vacuum provided insufficient vacuum to the air conditioner control system. This lack of vacuum caused the air conditioner air valves to partially shut and thus greatly reduced the cool air flow when accelerating. The two Mercury's were not checked to see if a similar problem occurred.

When converted to 4 cylinders, the vehicle's idle speed (neutral) typically increased several hundred rpm. However, as soon as the vehicle was placed in gear, idle speed dropped below normal idle (drive) speed and the vehicles had a tendency to stall, especially if the air conditioner was on. (The idle speed was not adjusted since readjustment of idle speed was not given in the ACDS instructions).

When cranking the vehicles (4 cylinder operation) the starter would momentarily stop due to the loads imposed by the 4 deactivated cylinders. This problem was more prevalent for warm engines. A limited check indicated peak starting currents were twice as high as normal. This indicates that there may be starting problems for vehicles with weak batteries or starting systems.

Although the vehicles accelerated much slower on 4 cylinders, once a cruise speed was achieved, the vehicles decelerated slowly when the driver's foot was removed from the accelerator. Therefore, there was negligible engine braking.

Appendix

TEST VEHICLE DESCRIPTION

Chassis model year/make-1979 Chevrolet Impala
Vehicle I.D. 1L47L9S115799

Engine

type.................................... Otto Spark, V-8, OHV
bore x stroke........................... 4.00 x 3.48 in/101.6 x 88.4 mm
displacement............................ 350 CID/5.7 liter
compression ratio....................... 8.3:1
maximum power @ rpm .... 170 hp/ 126 kW
fuel metering........................... 4 venturi carburetor
fuel requirement........................ unleaded, tested with indolene HO unleaded, and a commercial unleaded

Drive Train

transmission type .... 3 speed automatic
final drive ratio 2.41

Chassis

type .... 2 door sedan
tire weight............................. FR 78 x 15
curb weight .... 3840 lb/1742 kg
inertia weight .... 4000 lb.
passenger capacity...................... 6

Emission Control System

basic type.............................. EGR
Oxidation Catalyst

Vehicle odometer mileage................ 17050 miles at start of test program.

TEST VEHICLE DESCRIPTION

Chassis model year/make-1979 Mercury Capri

Vehicle I.D. 9F16F638851

Engine

type	Otto spark, V-8, OHV
bore x stroke	4.00 x 3.00 in./101.6 x 76.2 mm
displacement	302 CID/5.0 liter
compression ratio	8.4:1
maximum power @ rpm	135/101 kW.
fuel metering	2 venturi carburetor
fuel requirement	unleaded, tested with indolene HO unleaded and a commercial unleaded

Drive Train

transmission type	3 speed automatic
final drive ratio	2.47

Chassis

type	2 door sedan
tire size	CR 78 x 14
inertia weight	3500 lbs.
passenger capacity	4

Emission Control System

basic type	Air Pump EGR Oxidation catalyst

Vehicle odometer mileage	13,800 miles at start of program.

TEST VEHICLE DESCRIPTION

Chassis model year/make - 1979 Mercury Cougar
Vehicle I.D. 9H93F692442

Engine

type	Otto spark, V-8 OHV
bore x stroke	4.00 x 3.00 in/101.6 x 76.2 mm
displacement	302 CID/5.0 liter
compression ratio	8.4:1
maximum power @ rpm	135 hp/101 kW
fuel metering	2 venturi carburetor
fuel requirement	unleaded, tested with indolene HO unleaded and a commercial unleaded

Drive Train

tranmission type	3 speed automatic
final drive ratio	2.75

Chassis

type	2 door sedan
tire size	GR 78x 15
inertia weight	4500 lb
passenger capacity	6

Emission Control System

basic type	Air Pump EGR Oxidation catalyst

Vehicle odometer mileage	16,850 miles at start of test program

TABLE V

AUTOMOTIVE DEACTIVATOR SYSTEM (ACDS) TEST
ON 1979 CHEVROLET IMPALA
FTP Mass Emissions
grams per mile

Test No.		HC	CO	CO_2	NO_x	MPG
	8 Cylinder stock					
80-1805		.52	3.88	555	1.47	15.8
80-1807		.52	4.18	541	1.53	16.1
	8 cylinder w/ACDS					
80-1938		.84	9.08	530	1.46	16.2
80-1975		.83	9.54	529	1.49	16.2
80-2455		1.03	11.77	527	1.67	16.2
	4 Cylinder w/ACDS					
80-1829		.66	15.91	436	4.20	19.2
80-1833		.76	21.63	443	3.91	18.5
	4 Cylinder w/ACDS		Commercial unleaded			
80-1835		.85	23.88	439	4.08	18.5
80-1912		.73	20.84	441	3.99	18.6

TABLE VI

AUTOMOTIVE DEACTIVATOR SYSTEM (ACDS)TEST
on MERCURY CAPRI
FTP Mass Emissions
grams per mile

Test No.		HC	CO	CO_2	NO_x	MPG
	8 cylinder stock					
80-2016		.77	3.33	508	1.27	17.2
80-2020		.78	2.67	505	1.31	17.3
80-2151		.78	3.34	509	1.34	17.2
	8 cylinder w/ACDS					
80-2133		.79	3.45	501	1.44	17.4
80-2135		.80	3.62	502	1.51	17.4
80-3089		.92	4.97	507	1.32	17.1
	4 cylinder w/ACDS					
80-2421		.67	7.45	459	4.38	18.8
80-2423		.69	8.04	458	4.39	18.8
	4 cylinder w/ACDS Commercial unleaded					
80-2417		1.00	20.79	467	4.16	17.6
80-2419		.77	12.02	453	4.10	18.7

TABLE VII

AUTOMOTIVE DEACTIVATOR SYSTEM (ACDS) TEST
on MERCURY COUGAR
FTP Mass Emissions
grams per mile

Test No.		HC	CO	CO_2	NOx	MPG
	8 Cylinder stock					
80-1724		.61	2.95	562	2.51	15.6
80-1726		.62	3.88	560	2.31	15.6
	8 Cylinder w/ACDS					
80-1743		.62	3.60	548	2.47	16.0
80-2457		.75	5.33	554	2.18	15.7
	4 Cylinder w/ACDS					
80-1744		.73	12.33	499	4.73	17.0
80-1748		.71	10.20	501	4.41	17.1
	4 Cylinder w/ACDS Commercial unleaded					
80-2219		.73	12.88	500	4.89	17.0
80-2221		.64	12.00	507	4.82	16.8

TABLE VIII

AUTOMOTIVE DEACTIVATOR SYSTEM (ACDS) TEST
on 1979 CHEVROLET IMPALA
HFET Emissions
grams per mile

Test No.		HC	CO	CO_2	NO_x	MPG
	8 Cylinder stock					
80-1806		.11	.18	387	1.48	22.9
80-1808		.12	.10	379	1.43	23.4
	8 Cylinder after ACDS modification					
80-1937		.10	.01	360	1.23	24.6
80-1976		.10	.02	371	1.42	23.9
80-2456		.11	.44	394	1.46	22.5
	4 Cylinder w/ACDS					
80-1830		.19	4.88	302	1.84	28.6
80-1834		.21	6.08	304	1.72	28.2
	4 Cylinder w/ACDS Commercial unleaded					
80-1836		.47	19.32	283	1.86	28.2
80-1913		.33	12.92	294	1.98	28.1

TABLE IX

AUTOMOTIVE DEACTIVATOR SYSTEM (ACDS) TEST
on 1979 MERCURY CAPRI
HFET Mass Emissions
grams per mile

Test No.		HC	CO	CO_2	NO_x	MPG
	8 Cylinder stock					
80-2017		.24	.06	376	1.27	23.5
80-2104		.25	.05	375	1.32	23.6
80-2152		.24	.09	370	1.34	23.9
	8 Cylinder w/ACDS					
80-2134		.25	.03	371	1.35	23.9
80-2136		.15	.00	366	1.42	24.2
80-3090		.27	.29	381	1.34	23.3
	4 Cylinder w/ACDS					
80-2422		.13	1.55	355	2.17	24.8
80-2424		.12	1.38	346	2.07	25.4
	4 Cylinder w/ACDS Commercial unleaded					
80-2418		.13	5.96	355	2.06	24.3
80-2420		.13	2.86	350	2.09	25.0

TABLE X

AUTOMOTIVE DEACTIVATOR SYSTEM (ACDS) TEST
on 1979 MERCURY COUGAR
HFET Mass Emissions
grams per mile

Test No.		HC	CO	CO_2	NO_x	MPG
	8 Cylinder Stock					
80-1725		.17	.24	406	2.57	21.8
80-1727		.16	.37	400	2.51	22.1
	8 Cylinder w/ACDS					
80-1918		.17	.17	396	2.47	22.3
80-2458		.18	.95	403	2.37	21.9
	4 Cylinder w/ACDS					
80-1745		.16	3.65	358	2.63	24.4
80-1749		.15	4.94	367	2.64	23.6
	4 Cylinder w/ACDS Commercial unleaded					
80-2220		.12	2.52	361	2.81	24.3
80-2222		.12	4.13	364	2.52	23.9

TABLE XI

AUTOMOTIVE DEACTIVATOR SYSTEM (ACDS) TEST
on 1979 CHEVROLET IMPALA
Steady State Emissions
grams per mile *

Test No.	SPEED	HC	CO	CO_2	NO_x	MPG	Road Test Avg. MPG
	8 Cylinder Stock						
80-1809	0 mph*	2.90	.00	4957	1.47	.53	
80-1809	25 mph	.22	.00	302	.17	29.3	
80-1842	35 mph	.46	.00	360	.34	24.5	
80-1842	45 mph	.23	.00	346	.54	25.6	
80-1842	55 mph	.08	.00	372	1.30	23.8	
	8 Cylinder after ACDS Modification						
80-1827	0 mph	2.68	.00	4506	1.71	.50	
80-1827	25 mph	.23	.00	304	.19	29.1	
80-1828	35 mph	.31	.00	335	.34	26.4	
80-1828	45 mph	.16	.00	338	.65	26.2	
80-1828	55 mph	.07	.00	362	1.79	24.5	
	4 Cylinder w/ACDS						
80-1831	0 mph	.84	.15	4605	4.75	.53	@79° F
80-1831	25 mph	.09	.01	312	.17	28.4	39.9
80-1832	35 mph	.13	.00	261	.23	34.0	36.4
80-1832	45 mph	.07	.00	266	.57	33.3	34.6
80-1832	55 mph	.04	.00	304	1.21	29.2	29.2

*0 MPH (idle) speeds emission values are given in grams per hour and gallons per hour.

TABLE XII

AUTOMOTIVE DEACTIVATOR SYSTEM (ACDS) TEST
on 1979 MERCURY CAPRI
Steady State Emissions
grams per mile *

Test No.	SPEED	HC	CO	CO_2	NO_x	MPG	Road Test Avg. MPG
	8 Cylinder Stock						
80-2019	0 mph*	4.39	.00	4866	3.85	.56	
80-2019	25 mph	.29	.00	695	1.50	12.7	
80-2018	35 mph	.55	.14	323	.90	27.3	
80-2018	45 mph	.38	.00	343	.76	25.8	
80-2018	55 mph	.18	01	368	1.25	24.1	
	8 Cylinder after ACDS Modification						
80-2138	0 mph*	4.35	.00	4779	4.80	.53	@ 70° F
80-2138	25 mph	.16	.09	289	.71	30.7	29.9
80-2137	35 mph	.52	.00	314	.93	28.1	28.2
80-2137	45 mph	.39	.01	336	.81	26.3	26.4
80-2137	55 mph	.20	.01	360	1.39	24.6	24.9
	4 Cylinder w/ACDS						
80-2650	0 mph	3.85	.46	4882	16.99	.56	@ 83° F
80-2426	0 mph	5.49	.20	4086	44.06	.45	
80-2650	25 mph	.32	.07	204	1.83	43.2	40.1
80-2426	25 mph	.40	.18	210	2.09	42.0	
80-2650	35 mph	.21	.00	230	4.36	38.4	38.2
80-2425	35 mph	.21	.01	234	4.45	37.8	
80-2651	45 mph	.11	.01	316	.62	28.0	32.1
80-2425	45 mph	.10	.01	312	.66	28.4	
80-2651	55 mph	.07	.01	339	1.40	26.2	26.5
80-2425	55 mph	.07	.02	346	1.47	25.6	

* 0 mph (idle) speed emission values are given in grams per hour and gallons per hour.

TABLE XIII

AUTOMOTIVE DEACTIVATOR SYSTEM (ACDS) TEST
on 1979 MERCURY COUGAR
Steady State Emissions
grams per mile*

Test No.	SPEED	HC	CO	CO_2	NO_x	MPG	Road Test Avg. MPG
	8 Cylinder stock						
80-1838	0*	2.44	.00	4053	1.83	.46	@ 70° F
80-1838	25 mph	.12	.02	329	1.16	26.9	27.7
80-1837	35 mph	.40	.00	341	1.46	25.9	26.2
80-1837	45 mph	.18	.00	359	1.58	24.7	25.5
80-1837	55 mph	.13	.01	394	2.51	22.5	22.5
	4 Cylinder w/ACDS						
80-1746	0 mph*	2.36	1.08	4596	14.45	.53	@ 65° F
80-1746	25 mph	.14	.01	237	3.20	37.4	38.9
80-1747	35 mph	.19	.00	262	4.98	33.7	33.1
80-1747	45 mph	.15	.00	296	2.41	29.9	31.5
80-1747	55 mph	.11	.02	351	2.07	25.2	27.4
	4 Cylinder w/ACDS Commercial unleaded						
80-2269	0 mph*	3.46	.31	4131	7.98	.48	
80-2269	25 mph	.12	.00	237	2.94	37.3	
80-2273	35 mph	.15	.00	264	4.12	33.6	
80-2273	45 mph	.12	.00	297	2.15	29.8	
80-2273	55 mph	.08	.04	359	1.85	24.7	

* 0 mph (idle) speed emission values are given in grams per hour and gallons per hour.

TABLE XIV
Dynamometer Acceleration Tests on 1979 Chevrolet Impala
seconds

SPEEDS	8 Cylinder Indolene unleaded Run 1	Run 2	Run 3	ACDS 4 Cylinder Indolene unleaded gasoline Run 1	Run 2
0 - 5 MPH	1.0	1.5	1.2	1.2	1.0
0 - 10 MPH	1.6	2.2	1.8	2.6	2.1
0 - 15 MPH	2.2	2.8	2.4	4.0	3.5
0 - 20 MPH	2.8	3.3	3.1	5.7	5.2
0 - 25 MPH	3.4	4.0	3.7	7.4	6.9
0 - 30 MPH	4.2	4.8	4.5	9.0	8.5
0 - 35 MPH	5.0	5.6	5.2	10.8	10.3
0 - 40 MPH	5.8	6.3	6.1	12.5	12.0
0 - 45 MPH	6.8	7.3	7.0	14.4	13.9
0 - 50 MPH	8.0	8.6	8.2	17.2	16.9
0 - 55 MPH	9.5	10.0	9.6	20.3	19.9
0 - 60 MPH	11.0	11.6	11.0	24.0	23.3

TABLE XVa
Dynamometer Acceleration Tests on 1979 Mercury Capri
seconds

SPEEDS	8 Cylinder Indolene Unleaded Gasoline Run 1	Run 2	ACDS 4 Cylinder Indolene Unleaded Run 1	Run 2	Run 3	Run 4
0 - 5 MPH	1.3	1.4	2.0	1.9	1.5	1.3
0 - 10 MPH	2.1	2.1	3.2	3.2	2.8	2.6
0 - 15 MPH	3.0	2.8	4.6	5.1	4.4	4.1
0 - 20 MPH	3.9	3.7	6.4	6.8	6.2	5.9
0 - 25 MPH	4.7	4.6	8.1	8.4	8.0	7.6
0 - 30 MPH	5.7	5.5	9.8	10.2	9.8	9.4
0 - 35 MPH	6.8	6.4	11.9	12.3	11.9	11.5
0 - 40 MPH	8.0	7.5	14.3	14.8	14.3	14.0
0 - 45 MPH	9.3	8.5	17.5	18.0	17.5	17.2
0 - 50 MPH	10.8	9.8	21.7	22.6	21.0	20.7
0 - 55 MPH	12.9	11.4	25.4	26.0	24.9	24.5
0 - 60 MPH	15.2	13.0	-	-	29.8	29.0

TABLE XVb
Road Acceleration Tests on 1979 Mercury Capri
seconds

SPEEDS	8 Cylinder	ACDS 4 Cylinder Run 1	Run 2	Run 3	Run 4	Run 5
0 - 20 MPH		7.5	5.8	6.0	5.8	5.7
0 - 30 MPH	Not	11.5	9.2	9.5	9.5	9.8
0 - 40 MPH	Tested	15.5	13.4	13.5	13.4	13.3
0 - 50 MPH		23.5	19.7	20.0	20.2	20.0

TABLE XVIa
Dynamometer Acceleration Tests on 1979 Mercury Cougar
seconds

	8 Cylinder Indolene unleaded Gasoline		ACDS 4 Cylinder Commercial Unleaded		ACDS 4 Cylinder Indolene Gasoline	
SPEEDS	Run 1	Run 2	Run 1	Run 2	Run 1	Run 2
0 - 5 MPH	.8	.8	1.8	1.5	1.5	1.5
0 - 10 MPH	1.5	1.4	3.3	3.2	2.9	2.9
0 - 15 MPH	2.2	2.1	5.0	4.9	4.6	4.6
0 - 20 MPH	3.0	3.0	7.0	6.9	6.6	6.6
0 - 25 MPH	4.0	3.9	8.9	9.0	8.6	8.6
0 - 30 MPH	5.0	4.9	11.0	11.2	10.7	10.8
0 - 35 MPH	6.1	6.0	13.3	13.4	13.0	13.1
0 - 40 MPH	7.4	7.2	16.0	16.2	15.6	15.6
0 - 45 MPH	8.6	8.5	19.5	19.5	19.0	19.1
0 - 50 MPH	10.0	9.9	22.9	23.1	22.5	22.6
0 - 55 MPH	11.9	11.8	28.0	28.1	27.4	27.4
0 - 60 MPH	13.9	13.8	-	-	33.4	33.3

TABLE XVIb
Road Acceleration Tests on 1979 Mercury Cougar
seconds

	8 Cylinder Indolene unleaded Gasoline				ACDS 4 Cylinder Indolene Gasoline		
SPEEDS	Run 1	Run 2	Run 3	Run 4	Run 1	Run 2	Run 3
0 - 20 MPH	- -	- -	- -	- -	7.5	7.2	7.0
0 - 30 MPH	4.5	5.5	4.6	4.5	11.8	11.2	11.1
0 - 40 MPH	6.8	8.2	7.0	6.7	16.7	16.2	16.7
0 - 50 MPH	9.1	10.0	9.5	9.2	23.5	24.5	23.2

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INSTALLATION INSTRUCTIONS ON ANY GM V8 ENGINE

HOW IT WORKS

The purpose of this kit is to deactivate one-half of the engine. This is accomplished by releasing the fulcrum point of the rocker arm, thereby allowing the valves to stay closed on the deactivated cylinders.

The kit also provides means for attaching the pushrod to the hydraulic lifter and furnishes a spring which holds the pushrod and lifter assembly up and away from the cam shaft while deactivated.

INSTALLATION INSTRUCTIONS

Typical Chevrolet V-8 • (Mechanical Systems Only)

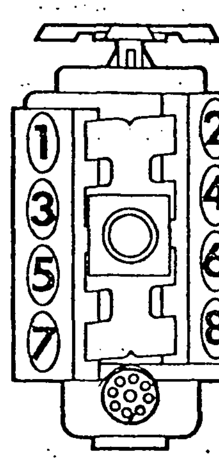
PREPARATION:

1. NOTE: This installation requires removal of the ignition distributor. If you don't know how to remove and replace it, get help either by referring to a service manual, or by talking with an experienced mechanic.
2. The top side of the engine should be cleaned, either with solvent or steam.
3. A set of rocker cover and intake manifold gaskets will be needed.
4. Special tool required, 1" HOLE SAW, with ¼" pilot drill and shank.

INSTALLATION:

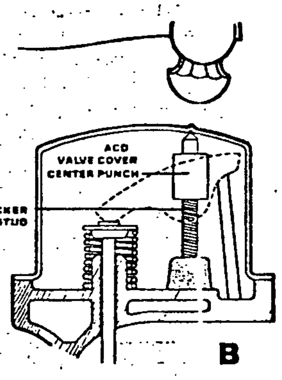
1. Disconnect ground cable clamp at battery terminal.
2. Drain coolant from radiator by opening drain cock on bottom radiator tank, or by removing bottom hose at radiator.
3. Before removing rocker arm covers, identify which cyldiners will be deactivated: Choose those with no access problems ON or OVER the rocker covers; that is, clear of OIL FILTER CAPS, PCV VALVE, MOUNT BRACKETS, or WIRING, ETC.
4. Remove rocker arm covers.
5. Remove ignition distributor, intake manifold, and all related lines, hoses, or wires. Use masking tape and felt pen to tag or mark any hoses, or wires, which might become mixed.
6. Remove rocker arms and pushrods for EVERY OTHER cylinder in the firing order: EITHER 1, 4, 6, 7; OR 8, 5, 3, 2. (See Ill. A.)

NOTE: Whichever cylinders you choose to deactivate, the combination should be as follows: on one bank, the FRONT and REAR cylinders will be affected; AND, on the other bank, the TWO CENTER cylinders. Pick a combination that will not interfere with the items listed in Step #3, above.



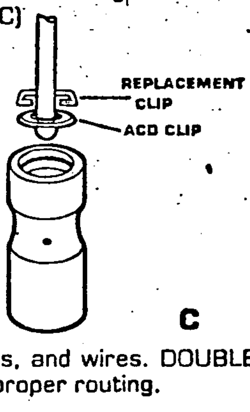
A

7. Remove the Adjusting nut, PIVOT BALL, and ROCKER ARM from the two STUDS of each of the affected cylinders. You may choose not to mix rocker assemblies, but if they are mixed by mistake, it is NOT critical. On BIG BLOCK Chevrolets, (396, 402, 427, 454 C1D) intake and exhaust pushrods are different lengths, but rocker assemblies are the same.
8. Remove the INTAKE AND EXHAUST lifters for each cylinder to be deactivated. Place on the bench, being as clean as possible. Remove the WIRE CLIP, PUSHROD CUP and flat disc from top of lifter. It is necessary to collapse the lifter for reassembly. You can do this by removing the inner plunger assembly and simply pouring out a portion of the oil underneath, OR, by depressing the ball check while pushing down on the plunger. You may now replace flat disc and pushrod cup. Do not install wire clip at this time.
9. Using a flat or triangular shape file, place a small groove 1/2" from top of pushrod. This is to help hold the ACD clip on the pushrod so it will not move.
10. Install Star clip onto a PUSHROD a distance of approximately 1/2" from the ball on the end. Slide 5/16" I.D. WASHER against CLIP and install SPRING onto PUSHROD. (See Ill. B)
11. After completing all 8 PUSHROD/SPRING assemblies, the KIT is ready to install in the engine.



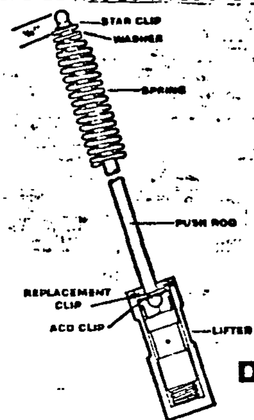
B

12. Install lifters into their respective holes in engine, without wire clips. Slide pushrod into hole above lifter.
13. Install ACD clip on ball of pushrod being sure not to distort ACD clip. (See Ill. C)
14. Push pushrod into lifter cup, down far enough to install wire clip (supplied with kit) into lifter groove on top of ACD clip. Repeat procedure on the other 7 lifter assemblies.



C

15. Re-install the intake manifold, ignition distributor, and all lines, hoses, and wires. DOUBLE CHECK all connections for proper routing.
16. Install ROCKER ARMS, PIVOT BALLS AND NUTS. For 4 cylinder operation, adjust valves with each CAM LOBE UP at its HIGHEST point. (Crank engine, watch pushrods—they should not move.) To operate in FOUR-CYLINDER mode, ROCKER ARMS are HELD UP so that the lifters do not contact the cam on the high side.
17. CLEAN ROCKER COVERS THOROUGHLY. INSTALL TRANSFER PUNCH on each ROCKER STUD to be deactivated, and mark ROCKER COVER (Tap with hammer) for 1" hole cutout. (See Ill. B)



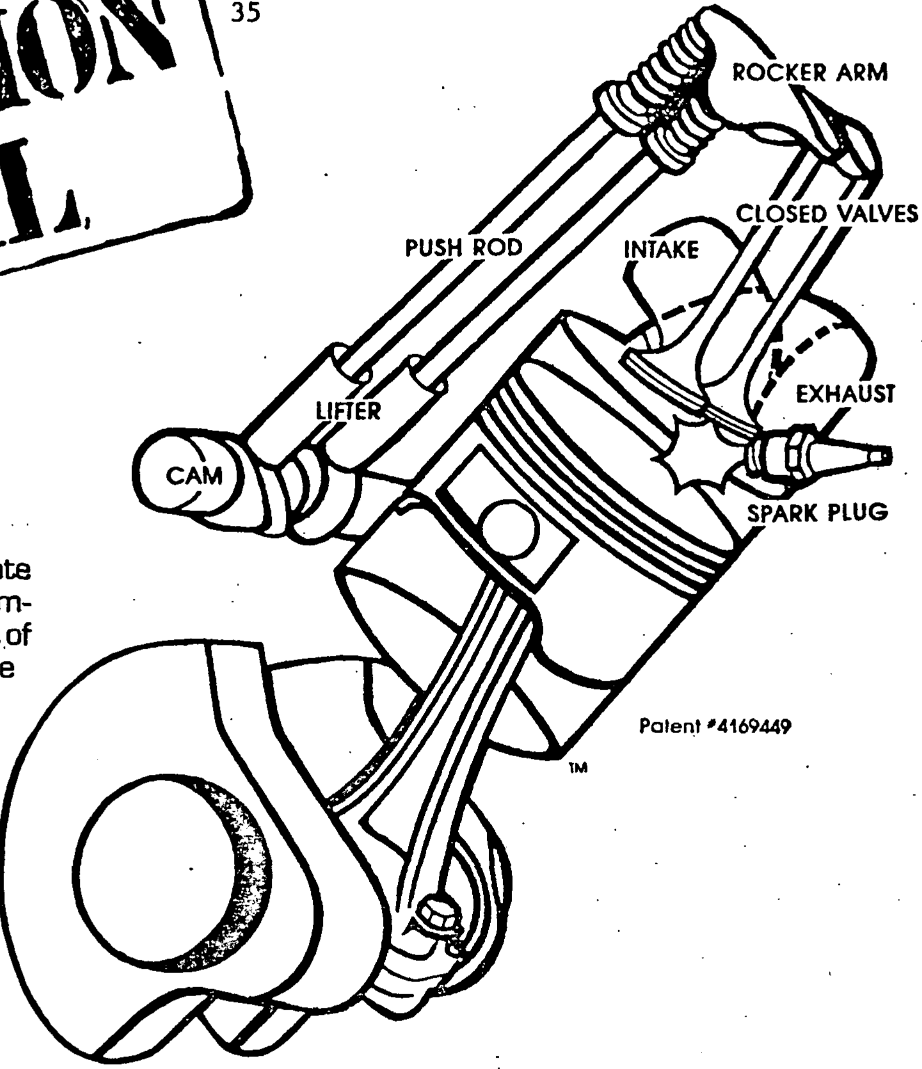
D

18. With the rocker cover held securely in a vise or bench clamp, align the PILOT DRILL of the 1" HOLE SAW with each PUNCH MARK; drill and cut out FOUR access holes. Remove all BURRS, inside and out, finishing with smooth half-round file or emery cloth. BE SURE NO METAL PARTICLES CAN FALL INTO ENGINE. Reinstall rocker covers.
19. To adjust ROCKERS for 8-CYLINDER operation, remove cup plugs in rocker covers, insert socket wrench, MAKING SURE cam lobe is DOWN. (This is most easily done by removing ignition distributor cap, and turning engine over until rotor points at spark plug wire location for that cylinder.) Then adjust as with a STOCK engine. Turn down adjustment nut until there is zero clearance. (Make sure you are not depressing lifter.) Advance nut 1/2 turn. This is the running adjustment.
20. For the BEST FOUR-CYLINDER economy and performance, tune to factory specification. If you have any specific tune-up problems or questions, contact ACDS inc. direct.

FOR MORE INFORMATION OR TO REORDER, WRITE TO: ACDS

1440 Hill St.
El Cajon, CA 92020
(714) 440-7385

INSTRUCTION MANUAL



HOW IT WORKS

The purpose of this kit is to deactivate one-half of the engine. This is accomplished by releasing the fulcrum point of the rocker arm, thereby allowing the valves to stay closed on the deactivated cylinders.

The kit also provides means for attaching the pushrod to the hydraulic lifter and furnishes a spring which holds the pushrod and lifter assembly up and away from the cam shaft while deactivated.

INSTALLATION INSTRUCTIONS

Typical Chevrolet V-8 • (Mechanical Systems Only)

PREPARATION:

1. NOTE: This installation requires removal of the ignition distributor. If you don't know how to remove and replace it, get help either by referring to a service manual, or by talking with an experienced mechanic.
2. The top side of the engine should be cleaned, either with solvent or steam.
3. A set of rocker cover and intake manifold gaskets will be needed.
4. Special tool required: 1 1/8" HOLE SAW, with ¼" pilot drill and shank.

ACDS INC. TM
RESEARCH & DEVELOPMENT

INSTRUCTION MANUAL

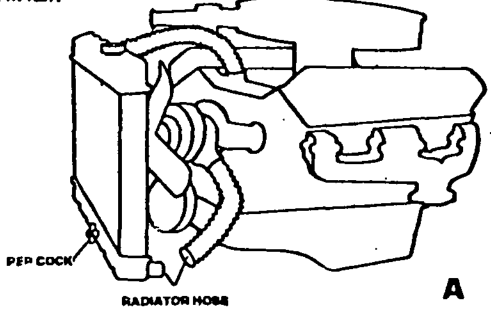
FOR INSTALLATION OF MECHANICAL ACD SYSTEM

ON SMALL AND BIG BLOCK CHEVROLETS

"AUTOMOTIVE CYLINDER DE-ACTIVATOR SYSTEM"

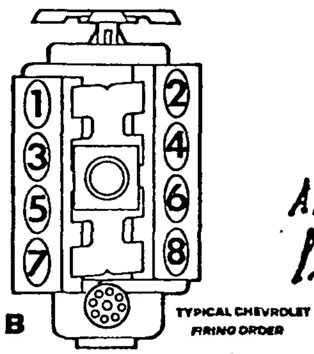
INSTALLATION:

1. Disconnect ground cable clamp at battery terminal.



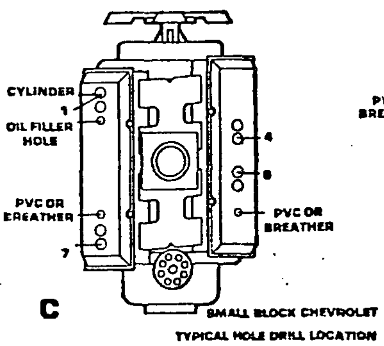
A

2. Drain coolant from radiator by opening drain cock on bottom radiator tank, or by removing bottom hose at radiator. [See Ill. A]

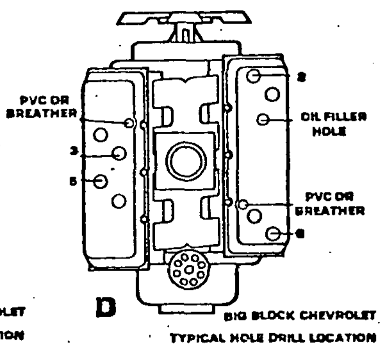


B

3. Before removing rocker arm covers, identify which cylinders will be deactivated: 1, 4, 6, 7 or 2, 3, 5, 8. Choose those with no access problems ON or OVER the rocker covers; that is, clear of OIL FILTER CAPS, PCV VALVE, MOUNT BRACKETS, or WIRING, etc. [See Ill. B]



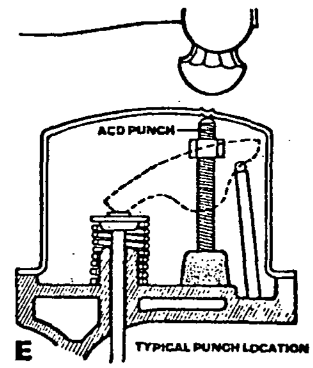
C



D

NOTE: Whichever cylinders you choose to deactivate, the combination should be as follows: on one bank, the FRONT and REAR cylinders will be affected; AND, on the other bank, the TWO CENTER cylinders. Pick a combination that will not interfere with the items listed in Step #3, above. [See Ill. C and D]

4. Remove rocker arm covers. CLEAN ROCKER COVERS THOROUGHLY. INSTALL TRANSFER PUNCH on each ROCKER STUD to be deactivated, and mark ROCKER COVER [Tap with hammer] for 1 1/8" hole cutout. [See Ill. E] With the rocker cover held securely in a vise or bench clamp, align the PILOT DRILL of the 1 1/8" HOLE SAW with each PUNCH MARK; drill and cut out FOUR access holes. Remove all BURRS, inside and out, finishing with smooth halfround file or emery cloth. BE SURE NO METAL PARTICLES CAN FALL INTO ENGINE. Reinstall rocker covers. After 13



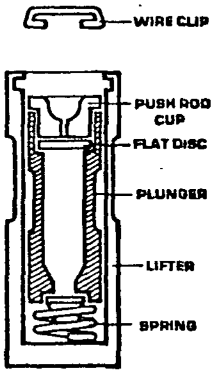
E

5. Remove ignition distributor, intake manifold, and all related lines, hoses, or wires. Use masking tape and felt pen to tag or mark any hoses, or wires, which might become mixed.

6. Remove Rocker Arms and Pushrods from cylinders to be deactivated.
Remove the Adjusting nut, PIVOT BALL, and ROCKER ARM from the two STUDS of each of the affected cylinders. You may choose not to mix rocker assemblies, but if they are mixed by mistake, it is NOT critical. On BIG BLOCK Chevrolets, [396, 402, 427, 454 C1D] intake and exhaust pushrods are different lengths, but rocker assemblies are the same.

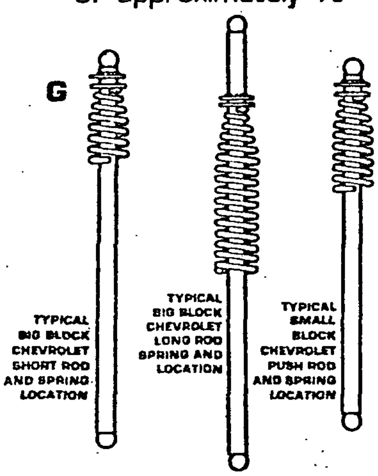
7. Remove the INTAKE AND EXHAUST lifters for each cylinder to be deactivated. Place on

the bench, being as clean as possible. Remove the WIRE CLIP, PUSHROD CUP and flat disc from top of lifter. It is necessary to collapse the lifter for reassembly. You can do this by removing the inner plunger assembly and simply pouring out a portion of the oil underneath, OR, by depressing the ball check while pushing down on the plunger. You may now replace flat disc and pushrod cup. Do not install wire clip at this time. [See Ill. F]



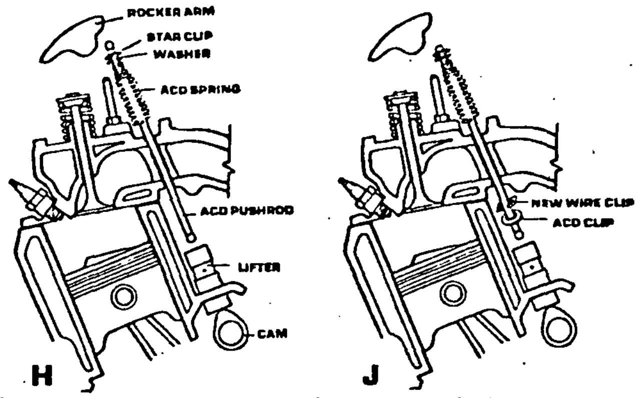
F

8. Install ACD clip onto a PUSHROD a distance of approximately ½" from the ball on the end. Slide 5/16" I.D. WASHER against CLIP and install SPRING onto PUSHROD. [See Ill. G] [This is pre-installed at ACDS factory but must be checked.]
NOTE: Big Block Chevrolet clip to be 1 5/8" from top of Long Rod. Short Rod ½" from top.



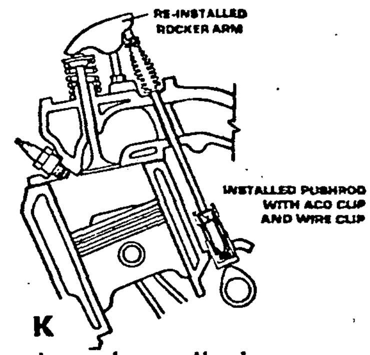
9. After completing all 8 PUSHROD/SPRING assemblies, the KIT is ready to install in the engine.

10. Install lifters into their respective holes in engine, without wire clips. Slide ACD pushrod, with springs installed, into hole above lifter. [See Ill. H]



Install ACD clip on ball of pushrod, being sure not to distort ACD clip. [See Ill. J] CUP UP

11. Push pushrod into lifter cup, down far enough to install wire clip [supplied with kit] into lifter groove on top of ACD clip. [See Ill. K] Should be inserted after clip. Repeat procedure on the other 7 lifter assemblies. [See Ill. K]



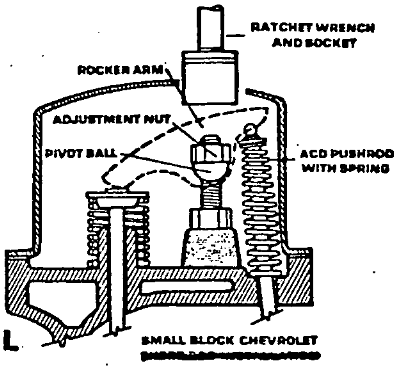
NOTE: Big Block Chevrolet Long Spring installed under Pushrod Guide. Short Spring installed on top of Pushrod Guide. [See Ill. M and N, on back]

12. Re-install the intake manifold, ignition distributor, and all lines, hoses, and wires. DOUBLE CHECK all connections for proper routing.

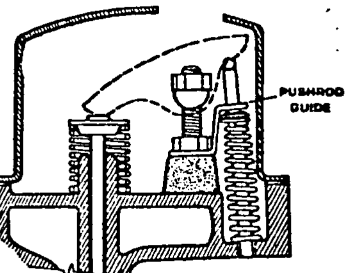
13. Install ROCKER ARMS, PIVOT BALLS AND NUTS. For 4 cylinder operation, adjust valves with each CAM LOBE UP at its HIGHEST point. [Crank engine, watch pushrods—they should not move.] To operate in FOUR-CYLINDER mode, ROCKER ARMS are HELD UP so that the lifters do not contact the cam on the high side. [See Ill. L on back]

14. To adjust ROCKERS for 8-CYLINDER operation, remove cup plugs in rocker covers, insert socket wrench, MAKING SURE cam lobe is DOWN. [This is most easily done by removing ignition distributor cap, and turning engine over until rotor points at spark plug wire location for that cylinder.] Then adjust as with a STOCK engine. Turn down adjustment nut until there is zero clearance. [Make sure you are not depressing lifter.] Advance nut ½ turn. This is the running adjustment. [See Ill. L, M and N]

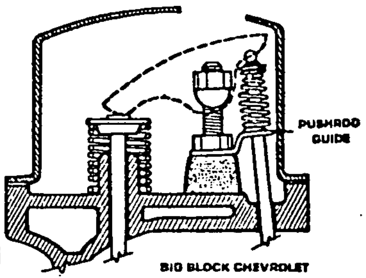
15. For the BEST FOUR-CYLINDER economy and performance, tune to factory specification. If you have any specific tune-up problems or questions, contact ACDS Inc. direct.



L SMALL BLOCK CHEVROLET



M BIG BLOCK CHEVROLET LONG ROD INSTALLATION WITH LONG SPRING



N BIG BLOCK CHEVROLET SHORT ROD INSTALLATION WITH SHORT SPRING

TROUBLE-SHOOTING

CONDITION	CAUSE	CORRECTION
Noisy on 4-cylinders	**1.** Valves, deactivated, still contacting cam shaft **2.** Loose timing chain	**1.** Loosen adj. nuts until all deactivated valve lifters do not contact cam shaft **2.** Replace chain and gears
Noisy on 8-cylinders	**1.** Improper valve adjustment	**1.** Recheck and correct adjustment
Rough idle on 4-cylinders	**1.** Idle speed too slow **2.** Vacuum leaks **3.** Improper idle adjustment **4.** Improper timing adjustment	**1.** Raise speed until smooth **2.** Check all hoses and connections; replace as necessary **3.** Adjust idle mixture screws **4.** Adjust timing
Rough idle on 8-cylinders	**1.** All of above on 4-cylinder model **2.** Tight valves	**1.** Same **2.** Recheck and correct
Stalls at stop light on 4-cylinders	**1.** Idle too slow in gear or operating Air Conditioner while in gear	**1.** Raise idle
Runs too rich on 4-cylinders	**1.** Dirty carburetor [choke sticking, etc. **2.** Jets in carb. too large	**1.** Clean carburetor and correct all adjustments **2.** Replace with smaller jets
Hard start on 4-cylinder [cold]	**1.** Choke not functioning **2.** Needs tune-up	**1.** Repair choke **2.** Tune engine
Hard start on 4-cylinder [hot]	**1.** Flooding **2.** Needs tune-up	**1.** Do not pump accelerator **2.** Check condition of carb. plugs, etc.

- Federal law requires that no changes be made to your pollution control equipment.
- For "Flip of a Switch" convenience on your Chevrolet, your Mechanical ACD System can be converted to a hydraulic system at a later date.

FOR MORE INFORMATION OR TO RE-ORDER, WRITE TO:

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RESEARCH & DEVELOPMENT
1440 HILL ST., EL CAJON, CA 92021 (714) 440-7585