Issue Paper

Technical Feasibility of a 2.0 g/test SHED Evaporative Emission Standard for Light Duty Vehicles and Trucks

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1. Statement of the Problem

Does the technology exist to meet a SHED evaporative emission standard of 2.0 g/test for light duty vehicles and trucks?

2. Facts Bearing on the Problem

a. Some 1974-76 production vehicles have evaporative emission levels below 2 g/test as measured by the proposed 1978 SHED testing procedure. Tests on 16 1975-76 2bbl Chevrolet Vegas showed that 10 of these vehicles averaged less than 2 g/test. Tests on a 1974 Plymouth Duster, a 1976 Datsun Pickup, a 1975 Volkswagen with fuel injection (FI), a 1975 Cadillac with FI, a 1976 Vega with FI, a 1976 Audi with FI and three Datsuns with FI have also yielded results of less than 2 g/test. Available test information for these eight types of vehicles is listed in Table I.

b. Under EPA Contract No. 68-03-2172, Exxon Research and Engineering modified the evaporative control systems and measured the evaporative and exhaust emission levels of six vehicles[(1)]. In the final modified form, the SHED evaporative emissions, including background, from each of these six vehicles averaged less than 2 g/test. For only one of these vehicles was the exhaust emissions of CO or HC significantly higher in the modified condition than in the stock condition. The results of these tests are contained in Table II.

c. Some manufacturer-developed experimental evaporative emission control systems have given SHED evaporative emission levels, including background, of less than 2 g/test. These systems and test data are given in Table III.

d. Tests have shown that well purged canisters substantially reduce diurnal emissions. This program was conducted at the EPA Vehicle Emissions Laboratory and results are shown in Table IV.

e. Background SHED emissions were determined on 15 1973-75 production vehicles (all at least 90 days old) by Exxon under Contract No. 68-03-2172. Seven of these vehicles had background levels of 0.1 g/test or less, and the average value was 0.34 g/test. These data are presented in Table V.

f. Variability of the SHED evaporative test was evaluated for a vehicle near the 2 g/test level in a recent MVMA-EPA cross-check test program. Within the five test sites, the standard deviation ranged from 3% to 12%. The standard deviation of all tests at all sites was 10%.

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(1) Clarke, P. J., "Investigation and Assessment of Light Duty Vehicle Evaporative Emission Sources and Control," Exxon Research and Engineering, EPA Contract # 68-03-2172, May 1976.

TABLE I. SHED Evaporative Tests on Production Vehicles

Vehicle	Engine	Tested By	No. of Tests	Average Diurnal, g	Average Hot Soak, g	Total, g	
						Range	Average
'75 Vega	140-2 bbl	ARB	1	0.4	1.5		1.9
'75 Vega	140-2 bbl	ARB	1	0.4	1.1		1.5
'75 Vega	140-2 bbl	ARB	1	0.6	1.2		1.8
'75 Vega	140-2 bbl	ARB	3	0.2	0.9	1.2-1.3	1.2
'75 Vega	140-2 bbl	ARB	1	0.3	0.8		1.1
'75 Vega	140-2 bbl	GM	5	1.37	1.02		2.39
'75 Vega	140-2 bbl	GM	2	0.40	1.59		1.99
'75 Vega	140-2 bbl	Exxon	2	0.27	4.48	3.82-5.67	4.75
'75 Vega	140-2 bbl	EPA	7	0.61	0.78	1.15-1.61	1.39
'76 Vega	140-2 bbl	EPA-MVMA	22	0.94	1.06	1.59-2.45	2.00
'76 Vega	140-2 bbl	GM	1	0.80	0.60		1.40
'76 Vega	140-2 bbl	GM	1	0.88	2.87		3.75
'76 Vega	140-2 bbl	GM	2	1.14	2.01	2.30-3.99	3.15
'76 Vega	140-2 bbl	GM	1	1.35	2.71		4.06
'76 Vega	140-2 bbl	GM	13	0.64	1.44		2.08
'76 Vega	140-2 bbl	GM	5	0.69	1.16		1.85
'76 Vega	121-FI (1)	GM	1	0.64	0.87		1.51
'74 Ply. Duster	225-1 bbl	Exxon	2	0.47	1.03	1.23-1.76	1.50
75 Cad.	500-FI	GM	2	0.25	1.07		1.32 (2)
'75 VW	97-FI	Exxon	3	0.67	1.34	1.55-2.61	2.01
'75 VW	97-FI	EPA	11	0.83	1.90	2.44-3.42	2.73
'75 VW	97-FI	ARB	1	-	2.90		-
'75 VW	97-FI	VW	3-5	-	-	3.8 - 5.8	-
'76 Audi	97-FI	VW	3-5	-	-	0.8 - 2.4	-
'76 Datsun	168-FI	Nissan	1	0.51	0.69		1.20
'76 Datsun	168-FI	Nissan	1	0.29	1.06		1.35
'76 Datsun	168-FI	Nissan	1	0.38	1.13		1.51
'76 Datsun	119-2 bbl	Nissan	1	0.26	1.67		1.93

(1) FI = Fuel Injected
(2) Includes a background level of 1.5 grams.

TABLE II. SHED Evaporative Tests on Vehicles Tested Under Contract No. 68-03-2172.

Vehicle	Engine	ECS Condition	Evaporative Emissions, g					Exhaust Emissions, g/mi[1]		
			No. of Tests	Average Diurnal	Average H. Soak	Total Range	Total Average	HC	CO	NOx
'75 Ford	351-2bbl	Stock	2	3.4	3.2	6.2 -7.1	6.7	0.54	6.75	1.62
		Modified	2	0.2	1.0	1.2 -1.3	1.2	0.52	4.44	1.87
'75 Pontiac	400-4bbl	Stock	2	0.4	7.1	7.2 -7.8	7.5	0.80	6.95	1.31
		Modified	3	1.2	0.7	1.6 -2.5	1.9[2]	0.68	4.05	1.36
'74 AMC	232-1bbl	Stock	2	0.5	10.3	10.8 -10.8	10.8	1.50	24.5	1.24
		Modified	2	0.3	0.9	1.2 -1.3	1.2	1.51	26.9	1.13
'74 Mazda	80-4bbl	Stock	2	0.2	10.4	10.5 -10.7	10.6	2.11	11.7	0.88
		Modified	2	0.6	0.9	1.3 -1.8	1.5	1.82	9.90	0.65
'74 Volvo	121-FI	Stock	2	4.7	3.2	7.1 -8.7	7.9	0.91	13.3	2.15
		Modified	2	0.7	0.4	0.4 -1.7	1.1	1.24	22.6	1.58
'75 Chrysler	440-4bbl	Stock	2	5.3	8.6	13.4 -14.6	13.9	2.32	23.2	1.98
		Modified	2	0.6	1.3	1.9 -2.0	1.9	1.10	13.3	1.83

(1) Average of 2 or more tests

(2) This data is for an underhood ventilating fan system. A PCV-purged canister system was later tested on this vehicle and average 1.6 g/test for 2 tests.

TABLE III. Manufacturer's SHED Evaporative Tests on Experimental Control Systems.

Vehicle No.	Make	Engine, CID	Carburetor	No. of Tests	Average Emissions, g Diurnal	Hot Soak	Total
1	Oldsmobile(1)	455	4 bbl	1	0.33	1.17	1.50
2	Chevelle(2)	250	1 bbl	1	0.64	1.23	1.87
3	Chrysler(3)	318	2 bbl	1	0.42	1.31	1.78
4	Chrysler(4)	225	1 bbl	7	0.72	1.05	1.78
5	Ford(5)	302	-	3	-	-	1.45
6	Ford(5)	400	-	3	-	-	1.54
7	Oldsmobile(6)	455	4 bbl	1	0.85	1.07	1.92
8	Oldsmobile(7)	455	4 bbl	1	0.74	0.96	1.70
9	Oldsmobile(8)	-	-	1	0.80	0.92	1.72
10	Oldsmobile(9)	-	-	2	0.48	1.18	1.66

(1) Dry canister, closed air cleaner snorkel during hot soak and float bowl vented to canister.
(2) Vapor purge valve, float bowl vented to canister and internal vent closed.
(3) 2-way carburetor bowl vent.
(4) Carburetor bowl vent to canister.
(5) Bowl vent valve, PCV purged enlarged canister, auxiliary canister, electronic air cleaner door and new gas cap.
(6) Proposed production ECS design with manually operated carburetor bowl switch.
(7) Proposed production ECS design with vacuum operated carburetor bowl switch.
(8) Experimental V-8 engine with bowl vent and air cleaner door, 1978 prep.
(9) Experimental V-8 engine with manual bowl vent switch, 1976 prep.

TABLE IV. Effect of Pre-purged Canister on SHED Diurnal Emissions from 1975 Model Vehicles

Model	Engine, CID	Carburetor	Proposed Procedure, g	Procedure with Pre-purged canister, g
Camaro	350	2 bbl	0.92	0.25
Vega	140	2 bbl	0.54	0.35
New Yorker	440	4 bbl	5.1	0.48
Matador	360	4 bbl	4.5	0.85
Average			2.77	0.48

TABLE V. SHED Background Measurements on Production Vehicles

Vehicle			Background Emissions, g		
Year	Make	Model	Cold	Hot	Total
'75	Chrysler	New Yorker	0.0	0.1	0.1
'75	Ford	Country Squire	0.0	0.1	0.1
'75	Mercury	Monarch	0.0	0.0	0.0
'75	Chevrolet	Vega	0.0	0.6	0.6
'75	Buick	LeSabre	0.1	0.3	0.4
'75	VW	Beetle	0.7	0.8	1.5 (1)
'74	AMC	Hornet	0.0	0.1	0.1
'74	Dodge	Dart	0.0	0.1	0.1
'74	Mercury	Comet	0.0	0.1	0.1
'74	Ford	Pinto	0.0	0.2	0.2
'74	Chevrolet	Nova	0.0	0.1	0.1
74	Oldsmobile	98	0.2	0.3	0.5
'74	Datsun	610	0.1	0.2	0.3
'74	Mazda	RX-4	0.5	1.1	1.6 (2)
'74	Volvo	144	0.1	0.1	0.2
'73	Plymouth	Fury III	0.1	0.7	0.8
Average (3)			0.09	0.25	0.34

(1) Source tests indicate the emissions are coming from the external enamel paint.

(2) Evidence of gasoline spillage in trunk.

(3) Omitting the 1974 Mazda.

3. Discussion

a. Table I indicates that most 1975 Vegas have evaporative emissions of less than 2 g/test. The evaporative control system (ECS) used on this vehicle is unique in the automotive industry. It uses the charcoal canister to store carburetor bowl vapors and the canister purges through a line into the PCV system during off-idle operation. Since this ECS was highly effective on its first application, the successful use of this system on other vehicles looks very encouraging. There is no technical reason why this basic purge system cannot be installed on other engines.

The ECS used on the Plymouth listed in Table I purges the canister through a line into the carburetor. Since data on only one of these production vehicles is available, the effectiveness of this particular engine-ECS combination is not as well established as that of the Vega. Similarly, there are only limited data on the carbureted Datsun listed in Table I. The Cadillac, VWs, Audi, 168 Datsuns and 121 Vega in Table I are fuel injected, so induction system losses are markedly reduced over non-controlled carbureted engines.

b. The purpose of Contract No. 68-03-2172 with Exxon Research and Engineering was to determine the amount of evaporative emissions from late model production vehicles, the source of these losses, and the hardware required to minimize these losses. The vehicles tested were obtained from rental fleets or from private owners. The Exxon data listed in Table I are from this program. Twenty vehicles were tested for the specific sources of evaporative losses and the largest source was found to be the engine air cleaner during the hot soak. Most of these vapors were emitted through the snorkel; however, some leaks were found at seams in the air filter housing and between the housing and the carburetor. These losses could be prevented by using a vapor tight air filter housing, fastening the housing securely to the carburetor, equipping the snorkel with a vapor tight door which would close when the engine is not running or cranking, and venting the carburetor float bowl to a carbon canister.

The second greatest source of vapor losses found by the Exxon study was the carburetor during hot soak. Most of these losses were emitted around the accelerator pump shaft. Some losses were also detected around throttle shafts. The losses around the accelerator pump shafts could most simply be prevented on most carburetors by fastening a vapor tight flexible boot around the shaft and against the carburetor. Such a device has already been used on some production carburetors. Another fix would be to switch from plunger to diaphram type accelerator pumps. These also are standard on some production carburetors. Leaks around throttle shafts would probably best be prevented by an improved fitting between the throttle shaft and the carburetor wall. Many of the vehicles tested did not have losses from around the carburetor throttle shafts. Therefore, preventing these losses on all carburetors should present no major problem.

The final source of emissions which contributed a substantial amount to the total loss from the production vehicles was the carbon canister. The quantity of emissions from this source was about equally divided between the diurnal and hot soak phases. These losses can be prevented by increasing the working capacity of the canister as previously discussed.

The next step in Exxon's contract was to modify or change the evaporative systems on 6 of the production vehicles they had tested and then evaluate the effect of these alterations on evaporative and exhaust emissions. The final results of these tests were previously presented in Table II. As shown, the six vehicles selected represent the four major U.S. vehicle manufacturers and two foreign manufacturers. Final modifications resulted in an average level for each vehicle of below 2.0 g/test, including background. Only one of the final 13 tests gave an emission of greater than 2.0 g (the 2.5 g result on the Pontiac).

A listing of the specific modifications and corresponding emission levels for each vehicle is contained in Attachments 1 through 6 of the Appendix. As listed, several different modifications were evaluated on some of the vehicles. A summary of these modifications is listed in Table VI. As shown in Table VI, canister purge into the intake manifold via the PCV line was installed on three of the vehicles and worked effectively. It was expected that a PCV purge would also be effective on the Chrysler and Pontiac, but other types of modifications were used on these vehicles in order to investigate other types of control systems. An underhood ventilating fan was used on the Pontiac; however, this is a more complex solution than a PCV purge system. After the originally scheduled tests were conducted on the modified vehicles, the Pontiac was equipped and tested with a PCV purge system (without the ventilating fan). Two evaporative tests gave results of 1.52 g and 1.75 g.

As shown by the vehicle descriptions in Attachment 1 through 6 of the Appendix, the six vehicles which were modified by Exxon were representative of popular models sold by major automotive producers. The engines in the cars produced by the three largest U.S. manufacturers were all medium or large V-8s, two of which had four barrel carburetors. Evaporative emissions from large engines with large carburetors are generally the most difficult to control. This is because the amount of vapors generated by these vehicles is large. So the level of control which was achieved by the Exxon program, should be more easily accomplished on vehicles with smaller engines. Consequently, results of this study strongly indicate that essentially all vehicles can be modified to give evaporative emissions of less than 2.0 g/test.

TABLE VI. Vehicle Modifications Under Contract No. 68-03-2172.

Vehicle	Modifications
1975 Ford	Canister replacement with PCV purge Seal-carb. leak Barrier-snorkel base Air cleaner leak sealing Canister bottom cap
1975 Pontiac	Bowl vent to canister Seal-carb. leak Canister bottom cap Air cleaner leak sealing Fan
1975 Chrysler	Canister replacement Canister bottom caps Bowl vent to canister Barrier-snorkel base Seal-carb. leak Air cleaner leak sealing
1974 Hornet	Canister replacement with PCV purge Seal-carb. leak Bowl vent to canister Air cleaner sealing Canister bottom cap Barrier-snorkel base
1974 Mazda	Bowl vent to canister Canister with PCV purge Fan Canister bottom cap
1974 Volvo	Canister Replacement Baffel between tank and muffler

c. Table III showed results of manufacturer's evaporative tests on non-production engine-ECS combinations which have given total evaporative levels of less than 2 g/test. On the Oldsmobiles, carburetor venting to the canister is part of the production ECS. The various modifications to these vehicles consisted of closing the carburetor to canister vent line during engine operation, use of a dry (well-purged) canister and blocking the air cleaner snorkle during the hot soak. The dry canister effect can be achieved in normal vehicle operation by either better purging of the current canister (assuming its dry capacity is sufficient) or by increasing the size of the current canister. Trapping vapors in the air cleaner consists of making the air cleaner essentially vapor-tight when the engine is not running or cranking. The experimental system used on the Chevelle (1.87 g/test) does require some changes to the production carburetor as listed in Table III.

The data on the 225 CID Chrysler Corporation vehicle consisted of seven tests on one vehicle with various configurations of carburetor bowl venting to the canister. The average of all seven tests was 1.78 grams, so it appears that this type of modification is sufficient to achieve a 2 g/test emission level. Data from one test was reported on a vehicle equipped with a 318 in^3 engine and a 2-way carburetor vent. The result of this test was 1.78 g as listed in Table III. The engine modification used on this vehicle was similar to that on the Chevelle listed in the same table. The 2-way carburetor bowl vent consists of a valve which vents the carburetor bowl to the carburetor throat during engine operation and to the canister when the engine is not running.

The system used on the Ford vehicles listed in Table III is a system which has already been developed to meet a 6 g/test standard.(2) Ford supplied test data on many vehicles which were equipped with this control system. Although most of these vehicles had evaporative emission levels greater than 2 g/test, the two listed vehicles did give emission levels below 2.0 g/test on all six tests (three tests per vehicle).

d. Table IV listed results of tests to determine if the working capacity of carbon canisters used in production evaporative systems was sufficient for the diurnal test. The first part of this experiment consisted of testing the production vehicles according to the proposed SHED procedure. Then the procedure was repeated, except that a well purged canister (same size and configuration as the standard unit) was placed on the vehicle following the cold soak period and just prior to the diurnal test. As Table IV shows, the pre-purged canisters lowered the diurnal emissions of all four vehicles. The amount of this reduction ranged from 0.2 g on the Vega to about 4 grams on the New Yorker and Matador. This indicates that the working capacity of the canisters was not sufficient. As

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(2) Ford Motor Company, "Comments in Response to the Notice of Proposed Rulemaking Published in Fed. Reg. 2022 et. seq., dated Jan. 13, 1976," Feb. 27, 1976.

demonstrated by the above discussed Exxon test program, this capacity can be increased by either improved purging of the present canister, use of a large canister or a combination of these two methods.

e. Table V listed the background emissions for 16 of the 20 vehicles tested by Exxon. Gasoline spills had occurred from an auxiliary fuel tank in the interior of the first four vehicles tested, and therefore realistic background data is not available for those cars. All vehicles were at least 90 days old. From Table V it does not appear that background emissions were related to vehicle age. In fact, except for the VW and the Mazda, the oldest vehicle had the highest background emissions. One-half of the 1975 vehicles had background levels of 0.1 g or less. From this data it appears that the variation in background level is dependent on characteristics of the specific vehicles. Limited testing for the source of emissions from the VW indicated that it originated from the exterior of the vehicle and probably from the paint. The enamel paint used on this vehicle apparently drives slower than the paint typically used on U.S. manufactured cars.

f. Attachment 7 in the Appendix lists the results of SHED evaporative emissions on a 1976 Chevrolet Vega. These data are from a cross-check program in which AMC, Chrysler, EPA, Ford and GM participated. At least three tests were conducted at each facility. For all tests conducted on this vehicle the standard deviation was 0.20 grams or 10% of the mean value. With this combined test-to-test and lab-to-lab variability of 10%, the maximum mean emission level a particular vehicle can have in order to be at or below 2.00 g on a single test at a 90% confidence level is 1.77 grams. Also, in the certification process, a retest can be requested if a vehicle fails the first test. For a 90% probability of passing at least one of two tests, again assuming a standard deviation of 10%, the vehicle mean is 1.90 g/test.

To compare the variability of these SHED tests with current exhaust emission variability, results of an exhaust correlation test between EPA and Ford are presented in Attachment 8 of the Appendix. This program consisted of 5 tests at each facility conducted according to the federal exhaust emission testing procedure. The car used was a 1977 Ford durability vehicle.

As shown by Attachments 7 and 8, the variability of the SHED evaporative tests was typical of the variability encountered in exhaust emission testing. The percent standard deviation for all evaporative test results is 10%, and the standard deviation for all exhaust HC, CO, and NOx test results is 14%, 13% and 6% respectively. Since relatively little experience has been gained with the SHED evaporative test as compared to the exhaust test, SHED variability should decrease with improvements and refinements in the procedure.

g. The proceeding parts of this discussion have shown that there are two basic methods of reducing evaporative losses from vehicles. The first method is reducing the amount of gasoline which evaporates, and the second method is preventing the gasoline which has evaporated from entering the atmosphere.

The amount of gasoline which evaporates from a fuel system is determined mainly by the volume of gasoline and the increase in temperature of the gasoline. Therefore, techniques for reducing evaporative losses by the first method are reducing fuel tank size, reducing carburetor gasoline bowl volume, heat shielding the fuel tank from exhaust and engine heat, and reducing carburetor temperatures by heat shielding and external cooling (ventilating underhood area with fans, louvers, etc.). The second method of vapor control consists of capturing and disposing of gasoline vapors. When the vehicle is operating, this is accomplished by ducting the vapors into the engine induction system. However, when the engine is not operating the vapors must be stored if they are to be disposed of by the engine. Locations where vapors can be stored are in the engine crankcase or induction system or in an external container such as an activated carbon canister. For maximum effectiveness, it is important that these storage devices do not leak gasoline vapors. As demonstrated by the previously referenced Exxon study, hydrocarbon leakage from vapor storage devices (air cleaners and carbon canisters) was the major source of evaporative emissions.

Most production and experimental vehicle evaporative control systems consist mainly of the second method of control (capture and disposal of generated vapors). This method has generally shown to have greater feasibility and be less expensive than preventing gasoline vaporization. The particular system which has currently shown to be most effective is the one used on the Chevrolet Vega. This system stores both fuel tank and carburetor vapors on activated carbon. These vapors are subsequently purged into the engine induction system at a rate which is determined by engine load (intake manifold vacuum signal). This system, even when used without closing the internal carburetor bowl vent or sealing the air cleaner snorkel during engine-off condition, has given SHED evaporative test results of less than 2 g/test on many production Vegas and on several modified vehicles. The use of sealed air cleaners or internal vent valves would be expected to reduce these emissions to even lower levels. There is no reason why this type system cannot be adopted to all carbureted engines.

h. An area of concern in regards to low evaporative emission levels is the effect on exhaust emission levels. In the Exxon contract study, the vehicles having lowest exhaust emissions were not adversely affected by the ECS modifications. However, at exhaust levels necessary to meet the statutory standards (.41 g/mile HC and 3.4 g/mile CO) there could be a significant interaction effect between evaporative and exhaust emissions. The size of any such effect would depend on the particular type of evaporative-exhaust control system combination.

The evaporative systems that might be expected to have the greatest effect on exhaust emissions are those which store a large portion of the vapors in the engine induction system. During engine cranking and/or start-up these vapors are drawn into the engine and can have a large effect on the air-fuel ratio. This type of interaction can be minimized (and perhaps essentially eliminated) by not using the induction system for vapor storage. Vapors stored in a canister can be purged into the engine during periods of relatively high air flow rates when the effect on overall air-fuel ratio should be negligible. This type of purging is used most effectively by the current production Vegas.

For catalyst equipped vehicles, the level of HC and CO exhaust emissions are very low under warmed-up conditions. For this reason it may be desirable to time delay canister purging until the catalyst bed is up to operating temperature. Another possible purging technique for catalyst equipped vehicles would be to inject the canister stored vapors into the exhaust system during warmed-up operation. Such an exhaust purge system should essentially eliminate evaporative-exhaust interactions.

4. Conclusions

The above discussion strongly indicates that existing technology can be applied to meet an evaporative standard of 2.0 g/test by the proposed SHED procedure. Based on recent variability tests, a vehicle which has a true SHED evaporative level of 1.90 g/test has a 90% probability of passing a 2.0 g/test standard. The data cited in this issue paper cover a wide range of vehicle types. The results show that some current production vehicles are below a 1.9 g/test level. Other vehicles have met a 1.9 g/test level after receiving some modifications to the production evaporative control system.

APPENDIX

APPENDIX V

TABLE I

SUMMARY OF EVAPORATIVE EMISSIONS FROM MODIFIED VEHICLES

Make: Ford "LTD"
Year: 75
No.: 1
Displ. cu. in./Litre: 351/5.75

	Modifications	Evap. Emissions, g/SHED Test	Remarks
I.a.	Purge from inside air cleaner element.		
b.	Barrier in air cleaner at base of snorkel.	6.1	
c.	Choke shaft passage sealed.		
II.	Steps a, b, c		
d.	Air horn to body gasket modified to allow more bowl vapors to be stored in air cleaner.	9.6	
III.e.	Purge to air cleaner snorkel as well as air cleaner.		

Measurements were made of purge rates for both an air cleaner and a snorkel purge system. Next, a curve of grams removed from canister vs. total purge volume was made. From these data it was estimated that a combination air cleaner-snorkel purge system would remove 13 to 15 grams from the canister during the SHED preconditioning period (4-LA-4s). This is not an adequate system because the combined diurnal and hot soak input to the canister is about 23 grams for the modified vehicle. Consequently, a PCV purge system was installed using a 1974 Vega canister which had been in daily usage up to this time.

	Modifications	Evap. Emissions, g/SHED Test	Remarks
IV.	PCV purge with Vega canister. The bottom of the canister is capped. An unmodified carburetor body to air horn gasket used along with modifications b and c above.	1.3 1.2	

Table II

Summary of Evaporative Emissions from Modified Vehicles

Make: Pontiac
Year: 75
No. : 2
Displ. cu. in./Litre: 400/6.56

Modifications	Evap. Emissions, g/SHED Test	Remarks
I.a. Vented carb. bowl to canister.		
b. Sealed leak around accel. pump shaft.	10.5 (diurnal)	
II. Steps a and b		Canister dried up before run.
c. Restriction in line from bowl to canister.	3.4	
III. Steps a, b, c		
d. Underhood ventilated with a fan.	1.6	Fan lowers carb. temp. about 30°F
e. Bottom on canister.	2.5	
	1.7	

NOTE: Upon completion of these tests, a Vega canister was installed, and tests were conducted without use of the underhood ventilating fan. Two repeat tests were performed and results were 1.52 and 1.75 g/test.

APPENDIX V

TABLE IV

SUMMARY OF EVAPORATIVE EMISSIONS FROM MODIFIED VEHICLES

Make: Chrysler
Year 75
No.: 21
Displ. cu. in./Litre: 440/7.21

Modifications	Evap. Emissions, g/SHED Test	Remarks
I Original ECS	13.4	Diurnal - 6.3 g, H.S. - 7.1 g
Original ECS	14.6	Diurnal - 4.4 g, H.S. - 10.2 g
II Modified ECS:		
(a) Two canisters in parallel used		
(b) Second carb. bowl vented directly to canister	1.9	
(c) Bottom on each canister	2.0	
(d) Barrier at base of snorkel		
(e) Accel. pump shaft leak sealed		

APPENDIX V

TABLE V

SUMMARY OF EVAPORATIVE EMISSIONS FROM MODIFIED VEHICLES

Make: Hornet
Year: 74
No.: 11
Displ. cu. in./Litre: 232/3.80

	Modifications	Evap. Emissions, g/SHED Test	Remarks
I.a.	Carb. bowl vented to the canister.	3.9	
b.	Accel. pump shaft leak sealed.		
II.	Steps a and b above - restriction in line from carb. bowl to canister.	3.1	
c.	Barrier installed in air cleaner at base of snorkel.		
III.	Steps a, b, c above		
d.	Bottom of canister closed.	2.5	
IV.	ECS modified to a PCV purge system using a 1974 Vega canister. Steps a, b, c, and d above also continued.	1.2 1.3	

APPENDIX V

TABLE VI

SUMMARY OF EVAPORATIVE EMISSIONS FROM MODIFIED VEHICLES

Make: Mazda
Year: 74
No.: 15
Displ. Cu In./Litre: 80/1.31 (Rotary)

Step	Modifications	Evap. Emissions g/SHED Test	Remarks
I	Both carburetor bowls vented to a 3 tube canister (Chrysler). Purge is through existing purge line to PCV. Original ECS used for diurnal.	4.8, 3.8	Hydrocarbon vapors escaping from snorkel.

II Next, the modifications indicated below were tested. In each case, the hydrocarbon level from the SHED test exceeded 2.0 grams.

1. Canister moved outside of engine compartment to a cooler environment.
2. Canister dried up on vacuum pump prior to diurnal and hot soak.
3. Air cleaner canister closed off and 3 tube canister used for both diurnal and hot soak.

At this point, additional source determination tests indicated hydrocarbon vapors emanating from carburetor throat due to fuel drippage. To alleviate pressure in the carburetor bowl, a fan installed to lower bowl temperature by ventilating the underhood engine compartment.

Step	Modifications	Evap. Emissions g/SHED Test	Remarks
III	Modifications for Step I. Underhood fan to ventilate underhood.	2.8	

At this point, the 3 tube canister was changed to a 4 tube Vega with a purge control valve. (Used canister from 1974 Vega.) High diurnal losses in above runs due to tank vapors passing into engine crankcase, then through PCV purge line into 3 tube canister. Vapors then moved out of the canister into the carburetor bowl and air cleaner through the vent line from the bowl to the canister. The purge control valve prevents this migration of vapors into the carburetor bowl and air cleaner.

Step	Modifications	Evap. Emissions g/SHED Test	Remarks
IV	Modifications for Step I with exception of replacing 3 tube canister with a 4 tube unit. Fan to ventilate underhood.	1.8, 1.3	

APPENDIX V

TABLE VII

SUMMARY OF EVAPORATIVE EMISSIONS FROM MODIFIED VEHICLES

Make: Volvo
Year: 74
No.: 17
Displ. cu. in./Litre: 121/1.98

Modifications	Evap. Emissions, g/SHED Test	Remarks
I.a. Equalizing valve modified so as to relieve fuel tank pressure at 0.5 psig.	0.4	CO and HC exhaust levels higher with modified ECS.
b. Baffle installed between fuel tank and muffler.		
c. American Motors canister used.	1.7	

Attachment 7

MVMA SHED CROSS-CHECK RESULTS

1976 Chevrolet Vega #76008

Test Laboratory		SHED Emissions (Grams) Diurnal	Hot Soak	Total
American Motors		.98	1.18	2.16
		1.06	1.12	2.18
		.84	1.06	1.90
		.86	.93	1.79
		1.03	1.19	2.22
	Mean	.95	1.10	2.05
	S.D.	.10	.11	.19 (9%)
Chrysler Corporation		.78	1.12	1.90
		.76	1.10	1.86
		.71	1.05	1.76
	Mean	.75	1.09	1.84
	S.D.	.04	.04	.07 (4%)
EPA		.77	1.19	1.96
		.86	1.16	2.02
		.78	1.28	2.06
	Mean	.80	1.21	2.01
	S.D.	.05	.06	.06 (3%)
Ford Motor Company		1.21	1.24	2.45
		.92	1.05	1.97
		1.15	1.19	2.34
		1.09	.85	1.94
	Mean	1.09	1.08	2.17
	S.D.	.12	.17	.26 (12%)
General Motors		.89	.92	1.81
		.82	1.18	2.00
		1.19	1.04	2.23
		1.25	.84	2.09
		1.05	.99	2.04
		.91	.89	1.80
		.69	.90	1.59
	Mean	.97	.97	1.94
	S.D.	.20	.12	.22 (11%)

Attachment 8

EPA-Ford Correlation Program with Durability Vehicle
7A1-400-5A1NP and 1977 FTP

Test Lab	Exhaust Emissions (g/mi)			
EPA		HC	CO	NOx
		.376	5.55	1.86
		.390	5.21	1.86
		.356	6.15	1.75
		.386	5.97	1.68
		.379	4.97	1.68
	Mean	.377	5.57	1.77
	S.D.	.013	.50	.090
	S.D., %	4%	9%	5%
Ford		.464	5.94	1.54
		.419	5.38	1.60
		.449	6.20	1.63
		.556	7.64	1.76
		.420	5.23	1.79
	Mean	.462	6.08	1.66
	S.D.	.056	.96	.107
	S.D., %	12%	16%	6%