Evaporative Emission Regulations for Light Duty Vehicles and Trucks (2 gram standard): Analysis of Comments

United States
Environmental Protection
Agency

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Mobile Source Air Pollution Control
Office of Air and Waste Managment
U.S. Environmental Protection Agency

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Introduction

The Notice of Proposed Rulemaking for Evaporative Emissions Regulations was published on January 13, 1976. This rulemaking included a proposal to implement a 2.0 g/test standard for the 1979 model year. Eleven motor vehicle manufacturers, one environmental organization, the research subsidiary of a petroleum company, and two governmental agencies separate from EPA responded to the request for comments on a 2.0 g/test standard. The respondents are listed in Table 1.

The responses were in general, directed toward the areas of concern identified in the preamble to the NPRM. Only the topics specifically pertaining to the proposed 2.0 g/test standard are addressed here. These have been divided into two major issues, and these are "Technical Feasibility and Lead Time Requirements of a 2.0 g/test Standard" and "Cost of a 2.0 g/test Standard". The issues that were generally applicable to both the 6.0 g/test and the 2.0 g/test standards were addressed in the 6.0 g/test regulatory package.

Most of the respondents argued that a two gram per test standard is unattainable, or at least not attainable by 1979 - especially if vehicle background hydrocarbon emissions are included in the measurement.

The analysis of comments consists of the following items:

1. A brief statement of each issue;

2. A description of each respondent's position regarding the issue;

3. A discussion and analysis of the issue; and

4. Summary and Recommendations.

Table 1

List of Respondents

1. American Motors Corporation (AMC)
2. Chrysler Corporation (Chrysler)
3. Council on Wage and Price Stability
4. Department of Commerce.
5. Exxon Research and Engineering Co. (Exxon)*
6. Fiat
7. Ford Motor Company
8. General Motors Corporation (GM)
9. Honda Motor Company (Honda)
10. International Harvester (IH)
11. Natural Resources Defense Council (NRDC)
12. Nissan Motor Company (Nissan)
13. Toyo Kogyo, Co.
14. Toyota Motor Sales, U.S.A., Inc. (Toyota)
15. Volkswagen (VW)

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* Although Exxon Research and Engineering Co., responded on behalf of its corporation, it should be noted that Exxon Research and Engineering was a contractor to EPA to explore evaporative emission control technology. The subsequent discussions differentiate between the contract study results and Exxon's corporate response to the NPRM.

Issue - "Technical Feasibility and Lead Time Requirements of a 2.0 g/test Standard"

An evaporative emission standard of 2.0 g/test was proposed for the 1979 model year vehicles. This section deals with the technical feasibility and lead-time requirements for meeting this regulation.

A. Summary of Comments

AMC - The question of inclusion or exclusion of the non-fuel hydrocarbon background into the emission level must be adequately answered before any consideration can be given to a 2.0 g/test standard.

Chrysler - Laboratory-to-laboratory test variability of 3.4 grams per test and replicate test variability of 4.0 grams per test is not uncommon. Tests on a six day old vehicle showed a hot background level during a hot soak of 2.62 grams. Thus, the proposed regulatory level of 2 grams per test is unrealistic if the SHED technique with its high degree of test variability, and the inclusion of non-fuel background emissions are utilized for certification purposes.

Chrysler also refers the EPA to Volume III of our "Progress Report on Chrysler's Efforts to Meet the 1977 and 1978 Federal Emission Standards for HC, CO, and NOx" (December, 1975). In Section III-C of that report, Chrysler itemized the thirty-six evaporative emission control system development tests that it had conducted in the 1975 calendar year through mid-November. From that program it is apparent that no evaporative system technique tested to date on the 440 engine even approached the 2 gram per test level* and that only limited success was obtained with the 225 and 318 engines.

"It can only be concluded that our present state of evaporative emission control cannot support a 2 gram per test control level and that considerably more development is required... The amount of development required to be conducted cannot feasibly be achieved before 1979 certification and most probably could not be effectively achieved even by the start of the 1980 certification... The State of the Art of control of evaporative emissions must be characterized as requiring the development of new technology to provide more effective control systems rather than application of existing technology."

Department of Commerce - Several major problems are posed by the 2 gram/test standard proposed for model year 1979 and later.

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* Results varied between 9.03 and 2.73 grams per test.

"(1) Is technology currently available to permit meeting the standard of 2 grams per test? It is by no means clear that this can be done. Technology is assumed to be available in the draft environmental impact statement.

(2) Interference from non-fuel evaporative emissions...The issue of certifying vehicles less than 60 to 90 days old, with high non-fuel evaporative emissions, has a real bearing on the impact on the environment and on the costs of compliance with the 2 gram standard. It must be granted that a widely varying non-fuel evaporative emission level is difficult to take into account. But, the very fact that it can be large in comparison with the 2 g/test standard means that it must be taken into account if the standard is to be realistically met. To age all test vehicles for 60-90 days is not a practical solution, since certification at present takes five to six months."

Exxon - "We believe that the proposed standard of 2 grams per SHED test, for the 1979 model year vehicle, is an over-restrictive standard. While such a 2 grams standard might be technically feasible, it is difficult to meet and might be economically unattractive. We would like to refer EPA to the recent work conducted at Exxon Research and Engineering Company under EPA Contract 68-03-2172 entitled "Investigation and Assessment of Light Duty Vehicle Evaporative Emissions." We believe that Table II of a status report dated January 23, 1976 submitted to Mr. Ron Kruse of EPA would be of special interest here. In our opinion, the cost-effectiveness relationship between the 6 and 2 gram standards should be better defined before adopting a specific standard for the 1979 model year vehicle."

Fiat - Assuming to have the 1979 models certified by the end of September 1978, this means that Fiat has to make its 1979 model year application for certification on November 1977. In the period of time which remains to that date, Fiat deems that it is very hard to extend to all its production for the U.S., especially to new models now under definition, evaporative systems which meet the 2 g/test standard, and to verify, that their compliance with the standard is assured for the "useful life" of any model of the car product line.

Fiat's opinion is that the reduction from a 6 g/test standard to a 2 g/test standard is not achievable in the course of only one model year. Fiat suggests to postpone to later model years the proposed 2 g/test standard and to adopt the 6 g/test standard for 1979.

Ford - The technological feasibility of the 2 gram standard specified in the proposal for 1979 has not been demonstrated. The few select production vehicles that have given test results of 2 g/test does not prove feasibility for every vehicle, engine and system combination. Nor does it suggest that there is sufficient technology to manufacture complying vehicles in 1979 in sufficient quantity to meet consumer demand.

Ford has supplied multiple SHED test data on 20 vehicles equipped with the system componentry necessary to meet the 6 g/test standard. The average emission level was 3.23 g/test and the test-to-test pooled standard deviation was 0.82g. Ford has no program in place to meet a 2 g/test standard and cannot get a program underway within the remaining time period to give any chance of meeting this standard in 1979.

A factor that complicates system development at a 2 g/test standard level is the vehicle background. A test involving 12, 1976 model vehicles indicates that the mean background level for a 90 day old vehicle is 0.75 g/test. The standard deviation is estimated to be 0.54 g at a 2 g standard, which produces a 1.79 g/test upper 95% confidence limit. This means the manufacturer must develop a zero fuel system evaporative level. This technology clearly is not available today, nor is it expected to be available in 1979. Ford recommends that the proposed 2 g/test standard be deleted until such time as a need for a 2 g/test SHED standard is shown in combination with proven technology.

<u>GM</u> - "The Administrator further states in the preamble (to the NPRM) that the technological feasibility of a 2 g/test standard for 1979 model year is supported by the California Waiver Hearing record...and by data developed by EPA. This information, the NPRM states, includes test results which show that the 1975 production Vega, a fuel injected Volkswagen and a 1974 Plymouth Duster currently generate evaporative emissions below 2 g/test when tested by the proposed method.

A note here on the definition of "technological feasibility is in order. <u>Technical</u> feasibility is defined by a demonstration on one car or one line of cars. <u>Technological</u> feasibility, on the other hand, means ability to produce <u>all</u> cars with similar performance.

General Motors contends that the Administrator has considered only <u>limited</u> and very <u>selective</u> data and that the technological feasibility for a 2 g/test standard for the entire line of General Motors vehicles, or for that matter all motor vehicles available for sale in the United States, has <u>not</u> been demonstrated. The preamble states that technological feasibility is established by "...data developed by EPA". We have requested these data from the Agency, which apparently includes measurements at or below 2 g/test only on the three cars cited above. It appears that EPA has no other test data on real cars at the 2 g/test level."

GM supplied test data on several vehicles. Included were results of 34 Vega 2 bbl tests covering nine vehicles. The average of these tests was 2.53 g/test. Further testing was done on the Vega vehicle with a 1 bbl carburetor. This 1975 regular production model exhibited evaporative emissions averaging 7.73 g/test. The 2 bbl carburetor vacuum operated bowl vent feature was added experimentally to the 1 bbl carburetor and resulted in an average of 2.28 g/test for five tests and other engines, with similar bowl vent equipment applied, do not even approach the 2 g/test level.

"The ability of General Motors to produce and market automobiles that will meet the 2 g/test Evaporative Emission Control Standard requires that we establish an engineering target level for the amount of evaporative emissions that our design and development vehicles must achieve to be considered candidates for certification...

Based on...car-to-car, test-to-test, and lab-to-lab variability, we conclude that 50% of our...Chevrolet Vegas with 2 bbl carburetor, would fail the proposed 2 g/test standard...

Further examination and analysis of these (Vega) data indicate that General Motor's engineering design target would have to be about 1.0 g/test (90% confidence) to meet the proposed 2 g/test standard... The technology to meet this standard has not been developed... It is important to note that this analysis assumes that background emissions would not be counted as evaporative emissions...If such a correction is not allowed, the engineering design target would necessarily be even lower.

...control to some level below 6 g may be achievable in the foreseeable future. However, no control system has yet been certified to a SHED standard, produced and made available in the marketplace for field experience. Until that experience is gained, we believe it is inappropriate to predict even the approximate level of a feasible standard below 6 g."

Honda - Honda requests the EPA to keep the 6 g/test standard for at least 2 years for the following reasons:

A. It is important to gain the experience of quality control of the production vehicles with the new evaporative emission control system incorporated including possible field problems.

B. Presently Honda does not have the technological feasibility to achieve the proposed 2.0 gr/test standard. The following will have to be solved in order to achieve the proposed standard.

   1. At the level of the 2.0 gr/test standard, hydrocarbons in background will probably occupy more than half of total hydrocarbons; therefore:

      a. It is necessary to research and develop an evaporative emission control system with which emits almost "0" evaporative emissions and

      b. It is necessary to research and develop technologies to reduce car background hydrocarbons.

   2. The research as to compatibility of the 2 gr/test evaporative emission standard with the more stringent exhaust emission standards to be regulated in the future.

3. Development of an evaporative emission control system compatible with the high altitude emission standards.

IH - IH believes that the 1979 standard of 2 g/test with the present State of the Art is virtually unattainable on IH vehicles with no background allowance. The 2 g/test standard should be delayed until a precise method of determining vehicle background emissions is available.

Natural Resources Defense Council - "We feel it is appropriate that the reasons for the Administrator's judgment that this 2 gram per test standard could not be applied to model year 1978 vehicles be articulated in greater detail in the materials supporting this rulemaking. The record indicates that some current production vehicles already apply technology capable of achieving the 2 gram per test standard and that if purged canisters were employed a test standard substantially lower than the 2 gram per test standard could be met."

Nissan - Tests indicate that production vehicles equipped with electronic fuel injection have emission levels which will probably meet a 2 g/test standard. Tests on three such vehicles ranged from 1.2 to 1.5 g/test. In the case of carbureted vehicles, Nissan is unable to estimate necessary lead time because it is not known yet what kind of measures should be taken to reduce emission down to the 2 g/test level. Nissan believes it will be able to have a better picture of this sometime around the fall of this year. Baseline tests on six production carbureted vehicles gave results of between 1.93 and 8.28 g/test. Tests on two modified carbureted vehicles yielded minimum emission levels of 1.73 and 2.70 g/test.

A 6 g/ test standard in 1978 followed by a 2 g/test standard in 1979 would be a heavy burden to the manufacturer. Nissan therefore requests that the 2 g/test standard be relaxed and also the enforcement of the relaxed standard be postponed at least one year.

"It is our thought that 3 gr/test will be the lowest one we can manage to comply with in 1980 model year, judging from the current status of our development activity."

Toyo Kogyo - "We would like the EPA to investigate the technical feasibility of a 2 g/test standard in 1979 before such a decision is made. The currently available data on our production vehicles show that the evaporative emissions resulting from something other than the carburetor and tank would amount to 1-6 g/test, the causes of which we do not yet know."

Toyota - "Our new evaporative emission control system progressed to such a level that we may be able to satisfy the proposed 6 g/test standard for the 1978 model year. However, we have the following problems when attempting to meet the proposed 2 g/test standard for the 1979 model year:

1. Hot Soak Loss

Our models generate 1 to 1.5 g/test of evaporative emission during the hot soak loss test when tested by the proposed test method. It can be expected that a small amount of fuel enters the carburetor venturis through the main or other nozzles due to the fuel vapor pressure in the float chamber and is then vaporized. A control valve may have to be provided in the main nozzle path in order to prevent this phenomenon... Considerable lead time will be required to develop such a system.

2. Diurnal Breathing Loss

Our models generate about 3 g/test of evaporative emissions during the diurnal breathing loss test.

a. ...a part of the HC vapor evaporated in the fuel tank is not stored in the canister but flows to the carburetor through the outer vent and is discharged into the enclosure through the inner vent and air cleaner. We are now reinvestigating the structure of a canister capable of preventing the vapor from by-passing the canister. However, at this stage, satisfactory results have not yet been obtained.

b. Our canister is designed to have sufficient HC vapor storage capacity when the ...purge air... flow reaches about 400 liters, which can be achieved by the current preconditioning. In our system, 100 liters of purged air flows during one cycle of UDDS. ...in order to solve this problem, the purge air flow has to be increased...It would take a great amount of time for us to develop such a purge control device because we must investigate the correlation between the exhaust emissions and purge air flow and also to perform the necessary recalibration of the carburetor.

When considering the lead time and future exhaust emission regulations, we cannot say, at this stage, that the proposed 2 g/test standard for 1979 model year would be technically feasible for us. We also think that since it is only one year after the implementation of the 6 g/test standard, it is not a reasonable idea to change to the 2 g/test standard because this may prevent development of a reliable control system. Therefore, we think it desirable that the 6 g/test standard is maintained for more than one year."

VW - To minimize the risk of failing certification tests, evaporative emission control systems will have to be designed for less than 1 g/test. Technical feasibility is not demonstrated by single measurement on only a very few vehicles. There is no doubt that technical solutions could be developed which are capable of meeting a 2 g/test standard. But there is no evidence that such a limit is necessary and efficient with regard to ambient air quality.

B. Discussion

Commentors were generally concerned with the technical feasibility and lead time requirements for meeting a 2.0 g/test standard. No automotive manufacturer stated that it could meet a 2.0 g/test standard in 1979. In fact, nearly all manufacturers stated that a 2.0 g/test standard in 1979 is infeasible. The manufacturers identified four major problem areas connected with the 1979 implementation of a 2.0 g/test standard. These problem areas are (1) test variability, (2) technical ability to reduce emissions from vehicles with stabilized background to a level required for certification, (3) vehicle background (i.e., non-fuel) emissions, and (4) lead time for equipment definition, development and production.

1. Test Variability - In regards to test variability Chrysler stated that laboratory-to-laboratory test variability of 3.4 g/test and test-to-test variability of 4.0 g/test is not uncommon. However, this test data is from a vehicle (Plymouth Valiant in the EPA-MVMA crosscheck program) whose mean emission level was about 7 g/test. And the numbers which are referred to as variabilities are ranges in the test data, not standard deviations. Since absolute variability is dependent on emission level, these numbers cannot be applied to vehicles with evaporative levels of around 2 g/test.

In addition to the Plymouth mentioned above, the EPA-MVMA crosscheck program also used a vehicle (Chevrolet Vega) which had a mean evaporative level of 2.0 g/test. The standard deviation of all test data obtained with this vehicle at the five test labs was 0.20g or 10% of the mean value. This standard deviation includes test-to-test variability and lab-to-lab variability. Another indication of the variability associated with certifying vehicles to a 2.0 g/test standard is given by data from the most recent EPA-MVMA emission correlation program. Although none of the vehicles in this program had evaporative emission levels as low as the Chevrolet Vega in the prior EPA-MVMA crossckeck program, the lowest emitting vehicle (an AMC Pacer) had a mean of 2.57 g/test. The standard deviation of all test data obtained with this vehicle (at six test labs) was 0.32g or 12.6% of the mean value. This standard deviation, like that for the Vega, also includes test-to-test and lab-to-lab variability. The amount of variability showed by these two vehicles is no greater than typical variability of HC and CO exhaust emissions, as desribed in reference (1).

In response to the NPRM, Ford reported replicate test data on 20 vehicles. Each vehicle was tested at least three times. The mean emission level was 3.23 g/test with a pooled standard deviation of 0.82g or 25%. Interestingly, the range of standard deviations on individual vehicles ranged from 1% to 60%. This indicates that some vehicles were much less repeatable than other vehicles. For the Vega tests in the MVMA crosscheck program, Ford tests had a standard deviation of 12%. This was not significantly higher than the other test labs, so this too indicates that the 25% standard deviation of the 20 vehicle tests at Ford was due to the high variability of some of the Ford vehicles rather than variability due to emission measurement equipment. Another factor which may contribute to the higher variability of the Ford vehicle tests as compared to the EPA-MVMA crosscheck tests, is that the Ford tests were done sometime before the crosscheck program was conducted. It is probable that interim improvements and refinements in the test procedure resulted in some reduction in test variability.

In their response to the NPRM, GM stated that based on car-to-car, test-to-test and lab-to-lab variability, 50% of the 2bbl Vegas would fail the proposed 2 g/test standard. This is an illogical statement. The percentage of vehicles predicted to be above a given emission level depends on the mean level of each vehicle, not on the variability of the test results. If 50% of 2bbl Chevrolet Vegas have an evaporative level greater than 2.0 g/test, it is because the mean emission level of over 50% of these vehicles is over 2.0 g, not because of high test variability.

Based on the data from nine Vegas, GM stated that an engineering design target of about 1.0 g/test would be required to meet a 2 g/test standard. This takes into account car-to-car, test-to-test and lab-to-lab variability. However, of the nine vehicles included in the data base, two of them had accumulated 50,000 miles and one had accumulated 35,000 miles. The average emission level for these three vehicles was 3.65 g/test, as compared to an average of 1.97 g/test for the other six vehicles. Consequently, data from all nine vehicles shows a high car-to-car variability (the car-to-car standard deviation was about 35%) and contributes heavily to the low engineering design target of 1.0 g/test.

The Vega used in the EPA-MVMA crosscheck program has generated information in regards to test-to-test and lab-to-lab variability of a 2.0 g/test vehicle. As stated earlier, 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. The much lower engineering design target of 1.0 g/test stated by GM is mainly a result of two factors--a single test per car assumption and a high car-to-car variability. And the car-to-car variability is high because of what appears to be deterioration of three high mileage vehicles.

More recent information regarding test variability was supplied by the manufacturers at the California 2.0 g/test waiver hearings in May, 1977 (10). Ford stated that, "Current SHED test variability experience indicates that results are only accurate to within $\pm$ 0.8 grams per test" (Hearing Record p. 288, line 9). Assuming that the upper and lower boundaries of this range are three standard deviations from the mean, as were the limits which Ford used for their background upper and lower values in Exhibit 2 of their post-hearing submittal (letter and attachment to Mr. Benjamin R. Jackson from D.R. Buist, June 9, 1977), this implies a standard deviation of 0.27 grams which is 13% of a 2.0 g level. This is consistent with the test variability shown in four tests on the one low-emitting AMC vehicle on which data was submitted (AMC June 3, 1977 post-hearing submittal from William C. Jones to Mr. B.R. Jackson). The mean of these tests was 1.26 grams and the standard deviation was 0.12 grams or 10% of the mean. GM also raised the issue of test variability. At the May 17, 1977 hearing they stated, "We estimated that, on the basis of test variability alone, a one gram per test design target was necessary to provide reasonable confidence that a system could be certified to a two gram standard. Our experience since that time has not altered that conclusion significantly" (Hearing Record p. 228, lines 4-9). However in their post-hearing submittal (letter and enclosures to Mr. Benjamin R. Jackson from T.M. Fisher, June 17, 1977), GM presented results of 40 tests on 1978 certification vehicles and stated, "Based on these more recent data and using accepted statistical analysis methods, our current engineering target is now estimated to be about 1.4 g/test to ensure that certification and production vehicles will meet the 2.0 g/test standard" (p.8). This target level would give 90% confidence of passing one test. The statistical information submitted by GM indicates that the confidence in passing one of two tests is about 1.73 grams. It is also noteworthy that the 40 tests on which the above statistical analysis is based are tests on 40 different vehicles (both data and durability vehicles included) so these results include vehicle-to-vehicle (within an evaporative emission family) variability as well as test-to-test and site-to-site (within one manufacturer's facility) variability.

2. Technical Ability to Reduce Emissions from a Vehicle with Stabilized Background to a Level Required for Certification - An area which was of concern to all manufacturers was the ability to lower vehicle evaporative emission levels to the level required for certification. The above discussion of variability showed that due to test-to-test and lab-to-lab variability, a vehicle's true emission level must be no higher than 1.90 g/test in order to be 90% confident of emitting no more than 2.00 g/test on at least one of two allowed tests.

In addition to the limited amount of 2.0 g/test SHED evaporative emission test results to which the Administrator referred in the notice of proposed rulemaking, considerably more such data are now available. Some of these data have been supplied by auto manufacturers and other organizations. Other data have been generated in an EPA contract study conducted by Exxon Research and Engineering(2), and certification data on 1978 model year vehicles is now available.

2.0 g/test data on production vehicles and modified vehicles are contained in reference (1). In that document, the compilation of test results from production vehicles (Table I) shows that eight different stock vehicle-engine combinations have given SHED test results of below 2.0 g/test. And Table II of reference (1) shows that ten different manufacturers developed experimental vehicle-engine combinations have yielded average SHED evaporative emission levels of less than 2.0 g/test.

As part of the Exxon evaporative study, six vehicles were modified in order to reduce evaporative emissions. These vehicles represented the four largest U.S. manufacturers and two foreign manufacturers. Each vehicle had SHED evaporative emissions greater than 6 g/test in production condition. These vehicles were a 1975 Ford LTD (351-2bbl), 1975 Pontiac Grand Prix (400-4bbl), 1975 Chrysler New Yorker (440-4bbl), 1974 AMC Hornet (232-1bbl), 1974 Mazda (80-4bbl) and a 1974 Volvo (121-fuel injected). In final modified form the average of the total evaporative emissions (including vehicle background) from each of these vehicles was 1.2, 1.9, 1.2, 1.9, 1.5, and 1.1 grams respectively.

Chrysler states that from their test work it is apparent that no evaporative system on their 440 engine even approached the 2.0 g/test level and only limited success was obtained with the 225 and 318 engines. In regards to the 225 engine, Chrysler supplied data on two vehicles (3). Various configurations of a carburetor bowl vent were tested on one of these vehicles. Seven tests were conducted using this type of device and five of these tests gave results of less than 2.0 g/test. The average for all seven tests was 1.78. In addition, one production Plymouth equipped with a 225 engine and standard bowl vent was given multiple tests by Exxon Research and Engineering (2). The average total evaporative emissions from this vehicle was 1.5 g. From available data, it appears that in addition to having "limited" success with the Chrysler 225 engine, the 2 g/test evaporative control system for this engine has already been defined.

In regards to the Chrysler 318 engine, Chrysler supplied results of four tests on one car which had been equipped with various types of carburetor bowl vents (3). Three of the tests were conducted with a one-way bowl vent and one test with a two-way bowl vent. The three test results with the one-way vent average 4.2 g/test, and the one test with a two-way bowl vent gave a test result of 1.78 g/test. So a two-way bowl vent may be adequate for this particular engine.

In Chrysler development tests with the 440 engine, the lowest evaporative emission level reported was 2.57 g (3). This was attained by using two 2-way carburetor bowl vents and cooling the intake manifold. Tests with the same vehicle indicated that sealing the air cleaner resulted in an evaporative emission reduction of about 2.0 g/test. For the tests which used the bowl vents, there was no indication that the leaks in the air cleaner had been sealed. If this were the case, then sealing the air cleaner in addition to bowl venting could well be expected to bring the evaporative emission level to below 2.0 g/test. Leaks were also found in the air-cleaner of the 440 engine in the Exxon study (2). In that test program these leaks were sealed in addition to using two carburetor bowl vents, two canisters and sealing a carburetor leak. The combination of these modifications reduced total evaporative emissions to an average of 1.9 g/test.

Ford supplied data on twenty vehicles which were equipped with their evaporative control system designed to meet a 6 g/test standard. The mean emission for all vehicles was 3.23 g/test. Two vehicles of this group received three repetitive tests each, and all six test results were below 2.0 g/test. One of these vehicles was equipped with a 302 engine and averaged 1.45 g/test. The other vehicle had a 400 engine and averaged 1.54 g/test. Tests on the other 302 and 400 equipped vehicles did not give average emission results as low as on these two vehicles. However, the two above cited vehicles do demonstrate that it is technically feasible to attain emission levels of less than 2.0 g/test on the 302 and 400 engines. And, as Ford stated, these low emission vehicles resulted from an effort to meet a 6.0 g/test standard. Ford had not yet made any effort to meet a 2.0 g/test standard.

One Ford vehicle was modified in the previously mentioned Exxon research program in order to reduce evaporative emissions. This was a 1975 LTD with a 351 engine. In addition to equipping the vehicle with a PCV purged canister (a part of the Ford system discussed above), vapor leaks were found and sealed in the air cleaner and around the carburetor choke shaft. This resulted in total evaporative emissions of 1.2 g and 1.3 g on repetitive tests. Hence, the technical feasibility of attaining a total evaporative emission level necessary to meet a 2.0 g/test level on three of Ford's largest sales volume engines (302, 351 and 400) has already been demonstrated.

In regard to GM's comments, it is agreed that the technological feasibility for a 2.0 g/test standard for all motor vehicles available for sale in the United States has not been demonstrated. To do this would require demonstrating that one vehicle from every vehicle evaporative emission family can achieve an evaporative level of less than 2.0 g/test. This would require modification and testing of about 100 vehicles. This is an unreasonable task for the regulatory agency. Such a task would do much more than show technical feasibility -- it would define the required hardware for essentially every vehicle. This is a job for the manufacturer, certainly not the Agency.

Additional test data was submitted by the manufacturers in regard to the California 2.0 g/test waiver request. The GM submittal of June 17, 1977 contained results of 160 evaporative emission tests on experimental systems. As GM pointed out, 72 (45%) of these tests have produced results below the 2.0 g/test level. In addition, GM supplied results of 40 tests on 0-mile 1978 certification vehicles. Thirteen (33%) of these test results were less than 2.0 g/test. Ford also submitted (in their June 9, 1977 document) development data on several of their vehicles. Their "best effort" data on six major vehicle-engine combinations were 0.90, 0.79, 1.81, 2.10, 1.53 and 3.36 g/test.

Since the California waiver hearings, additional test data was supplied by GM in a meeting with EPA representatives on August 8, 1977 (7). Test results were presented on six vehicles which were equipped with a new design 2500 cc canister and an engine air filter to which activated carbon was bonded. Four of the six vehicles were passenger cars and their emissions ranged from 0.73 to 1.37 g/test. The other two vehicles were a pickup and a suburban, both with 40 gallon fuel capacity, and their emissions were 2.35 and 2.85 grams, respectively. GM representatives indicated that if the durability of the air filters were satisfactory, which had not yet been established, their passenger cars should not have a problem in meeting a 2.0 g/test standard.

In a more recent meeting between EPA and GM (January 19, 1978), GM representatives stated that they had still not defined equipment which would permit certification of their large fuel capacity light-duty trucks to a 2.0 g/test standard (9). Data which they presented indicated that improved hot-soak control measures would be required on some of these vehicles in order to lower emissions to below 2.0 g/test. GM is currently involved in a development effort aimed at reducing evaporative emissions from these vehicles. In view of statements which have been made by Ford Motor Company representatives, it does not appear that control of evaporative emission from large fuel capacity light-duty and medium-duty trucks is significantly more difficult than light-duty vehicle control (Reference (10) p. 301-2).

Perhaps the strongest indicator of technical feasibility of a 2.0 g/test standard is the number of 1978 emission certification data vehicles which have given evaporative emission results of 2.0 g/test or less. As of September 27, 1977, 597 valid evaporative emission tests have been conducted on 1978 model year data (4,000 mi) vehicles at the EPA testing laboratory. Table I describes the test vehicles and results, and a distribution of the results is shown in Figure I. Of the 597 tests, 225 (38%) were less than 2.0 grams. These are the levels from vehicles which were designed to comply with a 6.0 g/test standard. For the 1978 model year, manufacturers are required to submit evaporative emission deterioration factors (DF) to the EPA for determining compliance. The average of the DFs currently submitted is about 0.3 grams. With this DF, a data vehicle must have an evaporative level of 1.7 g/test or less to meet a 2.0 g/test requirement. Of the 597 federal certification tests mentioned above, 158 (or 26%) were 1.7 g/test or less.

The data cited above covers a sufficient number of vehicle-engine combinations to confirm the technical feasibility of achieving a total SHED evaporative emission level of 2.0 g/test for essentially all vehicles with stabilized backgrounds.

3. Background Emissions - In their comments to the NPRM, most manufacturers were highly concerned about vehicle background (i.e., non-fuel) emissions. Since very new vehicles may have background levels which are higher than a 2.0 g/test standard, this concern is understandable. As was the case with the 6 g/test SHED standard, it is not the intention of the proposed rules to regulate "unstabilized" background emissions. However, due to the increased stringency of the 2.0 g/test standard, background emissions become of greater concern.

Ideally, background emissions would be measured each time the vehicle is tested and the evaporative emission test results would be adjusted accordingly (to exclude the "unstabilized" portion of the background emissions). However, for durability vehicles this is highly undesirable because the vehicle's fuel system must be removed or at least altered during the mileage accumulation process. And these changes could have some effect on both exhaust and evaporative emission levels.

For emission data vehicles, it also is not always possible to measure background emissions after the official tests are conducted. If the evaporative test results were to be adjusted for "unstabilized" background, the only means of knowing if a vehicle had passed an evaporative test would be to measure background. If a retest were then requested, the fuel system (which already had been removed) would need to be reinstalled and both exhaust and evaporative emissions retested. As in the case of the durability vehicle, the changes in vehicle performance which may be caused by this "tampering" make this test procedure unworkable.

Providing a correction factor which could be applied to results from the enclosure test to account for non-fuel evaporative emissions (e.g., allow subtraction of 1 g/test) has been considered. Such an allowance could be in the form of a single standard correction factor or different correction factors for different types of vehicles. However, in actual practice, a correction factor has serious disadvantages. It would be difficult to specify a reasonably valid correction factor due to the rapid change in non-fuel evaporative emission levels from new vehicles. Also, if vehicles with low non-fuel evaporative emissions were used, as is generally the case, the correction factor would serve as a bonus towards meeting the evaporative emission standard. It should be noted that even a 1.0 g/test allowance, as recommended by many manufacturers, does not account for very new, high background vehicles. So even an allowance of one gram will not solve this problem.

The existence of higher than stabilized vehicle background emissions for new vehicles can act to both lower and raise a vehicle's certified evaporative level. In the case of a mileage accumulation vehicle, the decrease in background emissions with time will result in lower than actual deterioration for the fuel system. On the other hand, an emission data vehicle which has higher than stabilized emissions will give higher evaporative test results than a stabilized vehicle. To minimize both these effects, it is desirable that all test vehicles have background emissions near their stabilized levels. This is at least as important for a 2.0 g/test standard as it was for the 6.0 g/test standard.

The background emissions issue was throughly evaluated as part of the 6.0 g/test regulatory package. Since that time additional information has been obtained regarding unstabilized non-fuel emissions from new vehicles and the ability to accelerate the reduction of these emissions. A study done at the EPA laboratory indicated that obtaining low background levels by artifically aging (baking) vehicles is feasible for a cost of roughly $500 per vehicle (4). Three vehicles were artificially aged by baking 4 times at a temperature of 160°F for 12 hours each time. Two of the vehicles were also aged by accumulating mileage on a chassis dynamometer. The background levels (hot plus cold) roughly 40 days after manufacturer were .22g, .21g and .35g for two 1976 Plymouth Volare's and a 1976 Chevrolet Nova, respectively. A second concentrated study of this problem was recently completed under contract to

EPA (5). This program was designed similarly to the program conducted at EPA. Background levels for the four 1976 model year vehicles which were artificially aged ranged .12g to .30g at roughly 15 days after manufacture.

The most recent background test data available is from a program conducted by Ford on two 1977 Granadas. One was built according to normal assembly line procedures, and the other was built omitting about 95% of the sealer/sound deadener. The vehicle without the sealer/sound deadener reached a stabilized background level of 0.2 grams approximately 10 days after build, and the standard vehicle reached a stabilized background level of 0.3 grams approximately 30 days after build. Since these nonfuel emission levels are lower than those submitted by Ford on previous model year vehicles, it appears that their 1977 model year vehicles have lower background levels.

4. Lead Time for Equipment Development and Production - The above discussion concludes that it is technically feasible to meet an enclosure evaporative standard of 2.0 g/test. This section discusses an appropriate model year for implementing this standard.

The automotive manufacturers, in their comments to the NPRM, unanimously agreed that implementation for the 1979 model year would be extremely difficult if not impossible. Honda, Fiat, and Toyota indicated that they need more than 1 year at a 6.0 g/test level in order to develop a 2.0 g/test system. Chrysler stated that development of a 2.0 g/test system cannot be achieved by the 1979 model year and is questionable for the 1980 model year. Ford stated there is no chance of meeting a 2.0 g/test standard by the 1979 model year. GM made no statement in regards to an implementation date for a 2.0 g/test standard.

In the NPRM comments, the manufacturers argued that the hardware has not yet been defined which will allow their vehicles to certify to a 2.0 g/test standard. GM and AMC maintained this same argument at the California waiver hearings for 1980. EPA's analysis indicates that the hardware required to meet this standard has not yet been defined for all vehicles. However, several production, experimental and 1978 certification systems have given results low enough to certify to a 2.0 g/test standard. This indicates that systems can be developed for essentially all vehicles. The manufacturer's comments to the NPRM did not, however, contain information on the time schedule required to define and develop this hardware. Due to the lack of this information, a lead time analysis was conducted using information submitted by the manufacturers at the hearings concerning California's waiver request for an evaporative emission standard in 1978. This analysis is contained in reference (6), which is contained in the Appendix to this Analysis of Comments section. As described in this reference, the longest expected tooling time for carburetor changes is 12 months. This is time required for any carburetor casting or tool changes including bowl vent modifications.

Prior to the beginning of tooling changes, the new equipment must be designed and developed. The manufacturers have stated that this process would take about 8 months for a 6.0 g/test standard. Since a 2.0 g/test standard is more stringent than a 6.0 g/test standard, it might be expected that more time would be required for the production design and development. However, the manufacturers have already gained considerable experience with evaporative control system design to meet the 6.0 g/test SHED standard. This is evidenced by the test results which have been obtained on 1978 certification vehicles, many of which are below 2.0 g/test. In view of this, it is concluded that eight months is also a reasonable length of time for production design and development of systems which would enable essentially all vehicles to meet a 2.0 g/test requirement.

With the above lead time considerations, and the start of engine production in June, 1979 (for a 1980 model year implementation), the date by which the necessary carburetor changes must be defined is determined. These dates for GM, Ford and Chrysler are October, 1977; November, 1977 and January, 1978; respectively. (This time schedule is presented in more detail in Table I of reference (6)).

Some recent lead time information was offered by GM in an August 8, 1977 meeting between GM and EPA representatives (7). GM representatives presented data which indicated that an evaporative control system consisting of an experimental 2500 cc canister and an air filter coated with activated carbon would allow their light duty vehicles to meet a 2.0 g/test standard. They stated that the canisters could probably be supplied in sufficient quantity for nationwide application for the 1980 model year; however, only enough air filters could be produced for California applications for 1980. Air filter production for nationwide application would require building of a new plant, making 1981 the earliest applicable model year. In a similar meeting on November 4, 1977, GM representatives stated that an air cleaner housing containing activated carbon might be used instead of the air filters; however, lead-time for this modification was not different (8). It is likely that the GM vehicles which certified at the 2.0 g level and below in 1978 will not need further control to comply with a 2.0 g/test standard. Of the 119 evaporative certification tests which were conducted on 1978 model year GM vehicles at the EPA test facility, 30 (or 25%) of the tests were 2.0 g or less. If, to meet a 2.0 g/test standard, air filters containing activated carbon are to be used on the vehicles which currently do not meet a 2.0 g level, approximately 75% of GM cars will be equipped with this device. In reality, less than 75% would require the special air filter since use of only the new larger canister and improved carburetor seals would be sufficient to lower emissions to below 2.0 g/test on some of the vehicles. The extent to which this would occur is not known.

C. Summary and Recommendations

SHED test variability at the 2.0 g/test level is no greater than variability of exhaust emission testing. Therefore, variability is not a unique problem associated with certifying vehicles to a 2.0 g/test SHED evaporative standard.

In regard to vehicle background (i.e., non-fuel emissions), it is desirable that all test vehicles have stabilized background levels. The manufacturer should be allowed to minimize these emissions from his test vehicle in any way (e.g., accelerated aging, sand blasting, removing upholstery, etc.) which does not violate provisions of the regulations. It is then recommended that the emission measurements include any remaining vehicle background level.

Test results on production, certification and modified vehicles show that an evaporative emission standard of 2.0 g/test (including stabilized vehicle background) is technically feasible; however, due to the time requirement for equipment definition, design, development, certification and production the proposed 1979 implementation date is impossible and a 1980 implementation date appears unachievable for some manufacturers. For example, General Motors has stated that some of the equipment (other than carburetors) which they are developing to meet a 2.0 g/test standard could be produced for nationwide application in 1981, but not for 1980. If carburetor machining changes are also required, the time by which the hardware must be defined is October 1977, assuming 1980 model year implementation. In addition, a 1981 implementation date will hopefully allow manufacturers time to develop hot soak control measures which will not require the use of equipment which needs periodic replacement, such as engine air filters. In view of these factors and in consideration of the manufacturer's unanimous objection to a 1980 California 2.0 g/test standard without an allowance for background emissions, it is recommended that the 2.0 g/test standard be promulgated for the 1981 model year. A more detailed analysis of the lead time issue is contained in reference (6), which is contained in the Appendix of this Analysis of Comments section.

Table I - SUMMARY OF 1978 CER CATION EVAP SHED TEST DATA PROCESSED: 14:08:20 SEP 27,

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TEST NO.	MFR. CODE	MODEL	DISPL.	NO. CYL.	NO. BBLS.	FUEL TANK VOLUME	DIURNAL LOSS	HOT SOAK LOSS	TOTAL LOSS
781745	570	9411SLAND CRUISER HT 2/4	257.9	6	2	16.4	-0.05	0.51	0.46
784531	260	21020HONDA ACCORD	98.0	4	3	13.2	0.29	0.27	0.55
783131	200	29035450SEL	276.	8	FI	25.4	0.15	0.43	0.58
785375'	363	28515MGB CONVERTIBLE	110.	4	1	12.3	0.28	0.30	0.58
785348	590	97005BUS STATION WAGON 22	120.	4	FI	14.6	0.19	0.40	0.59
783111	200	28040450SLC	275.	8	FI	23.8	0.18	0.42	0.60
783116	200	28025280E	167.5	6	FI	21.1	0.05	0.54	0.60
782874	120	70205AW 733I A	195.	6	FI	22.5	0.21	0.45	0.66
783114	590	42020DASHE SEDAN	97.	4	FI	11.9	0.18	0.49	0.67
782968	640	50054UDI FOX SEDAN	97.	4	FI	11.9	0.21	0.47	0.68
783980	260	21010HONDA CIVIC CVCC	91.0	4	3	10.6	0.30	0.40	0.69
782193	200	28045450SEL6.9	417.0	8	FI	25.4	0.21	0.50	0.71
782053	570	94005HILUX PICKUP TRUCK-I	133.6	4	2	12.2	0.40	0.33	0.73
782006	200	28030280SE	167.5	6	FI	25.4	0.27	0.47	0.74
781999	200	28020230	141.	4	1	21.1	0.22	0.54	0.76
784532	260	21010HONDA CIVIC CVCC	91.0	4	3	10.6	0.38	0.38	0.76
782205	200	28040450SLC	275.	8	FI	23.8	0.36	0.42	0.77
782645	600	43015264	163.	6	FI	15.8	0.25	0.53	0.77
784276	260	21020HONDA ACCORD	98.0	4	3	13.2	0.35	0.42	0.77
781807	570	94015LAND CRUISER HT 2/4	257.9	6	2	16.4	0.34	0.45	0.79
784615	363	28505 IDCEI	91.0	4	1	7.5	0.33	0.47	0.79
783614	120	7005 BMW 320I	121.3	4	FI	15.2	0.31	0.49	0.80
782001	200	28025280E	167.5	6	FI	21.1	0.25	0.55	0.81
782426	600	43015264	163.0	6	FI	15.8	0.18	0.63	0.81
784553	260	21005HONDA CIVIC 3DR	75.0	4	2	10.6	0.28	0.54	0.81
782192	200	28035450SEL	275.	8	FI	25.4	0.30	0.52	0.82
782760	200	28045450SEL6.9	417.0	8	FI	25.4	0.17	0.64	0.82
781394	570	94015LAND CRUISER HT 2/4	257.9	6	2	16.4	0.45	0.39	0.85
783125	640	5005AUDI FOX SEDAN	97.	4	FI	11.9	0.23	0.62	0.86
782562	30	19019FAIRMONT	200.	6	2	16.0	0.08	0.75	0.86
782201	200	28040450SL	275.	8	FI	23.8	0.42	0.45	0.88
782759	200	28030280SE	167.5	6	FI	25.4	0.47	0.40	0.88
781634	40	10005LE	350.0	8	FI	21.0	0.29	0.61	0.90
782846	640	5005AUDI FOX SEDAN	97.	4	FI	11.9	0.34	0.57	0.91
781495	570	39025CELICA LIFTBACK GT	133.6	4	2	16.0	0.65	0.29	0.95
782512	590	42020DASHER SEDAN	97.	4	FI	11.9	0.37	0.61	0.98
781780	550	70005COURIER PICKUP	109.6	4	2	17.4	0.55	0.44	0.99
782324	120	7005	121.3	4	FI	15.2	0.38	0.61	0.99
782464	570	94023LAND CRUISER WG1 2/4	257.9	6	2	21.7	0.52	0.37	0.99
783180	30	19019 FAIRMONT	201.	6	1	16.0	0.13	0.85	0.99
783782	350	15005B210 HATCHBACK HSP	1397.	4	2	11.4	0.42	0.56	0.99
784449	260	21010HONDA CIVIC CVCC	91.0	4	3	10.6	0.49	0.51	0.99
784613	530	40015SPITFIRE	91.0	4	1	8.7	0.50	0.40	1.00
783501	30	19019 FAIRMONT	201.	6	1	16.0	0.15	0.86	1.01
782424	570	94015LAND CRUISER HT 2/4	257.9	6	2	16.4	0.33	0.68	1.02
783059	570	39030CRESSIDA SEDAN	156.4	6	2	17.2	0.59	0.44	1.03
784372	30	19015 MUSTANG II 2DR(69F)	140.	4	2	13.0	0.23	0.81	1.04
783583	590	42005BEETLE CONVERTIBLE	97.	4	FI	10.6	0.25	0.80	1.05
781836	30	19015 MUSTANG (69F)	140.	4	2	13.	0.32	0.76	1.07
781895	30	19005 PINTO (62B)	140.	4	2	13.	0.42	0.65	1.07
783489	570	39005COROLLA 4DR SEDAN	71.2	4	2	13.2	0.73	0.35	1.08
783561	120	7020BMW 733I	196.	6	FI	22.5	0.19	0.90	1.09
784747	570	94005HILUX PICKUP TRUCK 2	133.6	4	2	16.0	0.45	0.63	1.09
784151	570	94005HILUX PICKUP TRUCK 2	133.6	4	2	16.0	0.48	0.63	1.11
784247	30	19025 GRANADA 2DR (66H)	302.	8	2	19.2	0.19	0.92	1.11
784571	230	18035LANCIA BETA SCORPION	107.	4	2	15.	0.41	0.71	1.12

781717	30	19019FAIR[illegible] I (54H)	140.	4	2	16.	0.30	0.83	1.13
782506	590	42010RABBIT	89.	4	FI	10.5	0.41	0.73	1.14
783285	40	33010SUNBIRD SAFARI SW	151.0	4	2	16.0	0.46	0.68	1.14
783345	260	21015CIVIC CVCC 5 DR WGN	91.0	4	3	11.1	0.27	0.86	1.14
782151	30	19005 PINTO (62B)	140.	4	2	13.	0.59	0.56	1.15
783501	30	70010 F-100 REG CAB LWB	300.	6	1	20.2	0.29	0.85	1.15
783994	570	39005COROLLA 2 DOOR SEDAN	96.4	4	2	13.2	0.70	0.45	1.16
784184	30	19055 THUNDERBIRD (60H)	400.	8	2	22.0	0.51	0.65	1.16
781723	40	10005LF	350.0	8	FI	21.0	0.35	0.82	1.17
782532	120	7005	121.3	4	FI	15.2	0.39	0.77	1.17
782145	600	43005244	133.	4	FI	15.6	0.43	0.75	1.18
78250.	590	42010RABBIT	89.	4	FI	10.5	0.42	0.78	1.19
78301-	590	42030DASHER STAT. WAGON	97.	4	FI	11.9	0.34	0.85	1.19
783976	30	19025 GRANADA	302.	8	2	19.2	0.22	0.97	1.19
784212	30	19015 MUSTANG II 2DR(69F)	140.	4	2	13.0	0.26	0.93	1.19
782380	30	19019 FAIRMONT	200.	6	1	16.0	0.12	1.09	1.20
782791	570	39005COROLLA 2DR SEDAN	96.9	4	2	13.2	0.94	0.28	1.21
781891	570	94015LAND CRUISER HT 2/4	257.9	6	2	16.5	0.40	0.83	1.23
783541	40	33005SUNBIRD HATCHBACK CP	151.0	4	2	18.5	0.64	0.58	1.23
781831	560	27020MAZDA GLC	77.6	4	2	10.6	0.35	0.89	1.24
782477	290	55005	110.8	4	2	13.2	0.35	0.88	1.24
782832	590	42005BEETLE CONVERTIBLE	97.	4	FI	10.6	0.67	0.57	1.24
782975	30	19019 FAIRMONT	140.	4	2	16.	0.19	1.05	1.24
784051	30	70015 F-100 VAN LWB	300.	6	1	22.1	0.34	0.90	1.24
781633	40	10005LF	350.0	8	FI	21.0	0.50	0.75	1.25
781656	30	19015 MUSTANG (69F)	140.	4	2	13.	0.27	0.98	1.25
782932	30	70010F-100 LWB	302.	8	2	20.2	0.36	0.90	1.25
782994	30	70010 F-100 SWB	302.	8	2	20.2	0.40	0.87	1.26
781930	30	19019FAIRMONT	200.	6	2	16.0	0.21	1.06	1.27
782802	40	12030MALIBU COUPE	305.	8	2	17.5	0.75	0.52	1.28
782740	490	16015280-Z9	97.5	4	2	15.8	0.46	0.83	1.29
782804	40	33015PHOENIX LJ	151.	4	2	21.0	0.63	0.66	1.29
783302	30	70010 F-100 SWB	302.	8	2	19.2	0.42	0.87	1.29
782754	10	85005CJ-7	258.	6	1	14.8	0.37	0.93	1.30
782812	30	19019 FAIRMONT	200.	6	1	16.0	0.16	1.15	1.31
783607	30	70010 F-100 LWB	302.	8	2	19.2	0.32	1.00	1.32
783663	40	12030MALIBU COUPE	200.0	6	2	17.5	0.64	0.68	1.32
782576	530	40012TR-8	215.	8	2	14.5	0.37	0.96	1.33
782088	30	19019FAIRMONT (54H)	140.0	4	2	16.0	0.52	0.82	1.34
782574	530	40012TR-8	215.	8	2	14.5	0.48	0.85	1.34
784654	250	21010HONDA CIVIC CVCC	91.0	4	3	10.6	0.63	0.71	1.34
782492	120	7010	182.	6	FI	16.4	0.32	1.03	1.35
783213	570	39005COROLLA LIFTBACK SR5	96.9	4	2	13.2	0.97	0.39	1.36
783097	230	13040X1/9	78.7	4	2	12.2	0.50	0.87	1.37
783308	30	70010F-100 SWB REG.	351.0	8	2	19.2	0.39	0.98	1.37
782066	30	70010 F-100 LWB REG CAB	351.	8	2	20.2	0.33	1.05	1.38
782401	10	85005CJ-7	304.	8	2	14.8	0.35	1.03	1.38
782834	590	42005BEETLE CONVERTIBLE	97.	4	FI	10.6	0.63	0.75	1.38
784206	30	19005 PINTO 2 DR.	140.	4	2	13.0	0.34	1.03	1.38
783072	10	85005CJ-7	304.	8	2	14.8	0.46	0.93	1.39
783371	30	19010 PINTO S.W.	140.	4	2	14.	0.26	1.14	1.39
783853	10	85005	304.	8	2	14.8	0.48	0.91	1.39
782247	290	55005LUV-2	110.8	4	2	13.2	0.36	1.04	1.41
782184	40	10010SS	425.	8	FI	24.5	0.63	0.80	1.42
781603	30	19010 PINTO S.W. (73)	171.	6	2	14.	0.24	1.20	1.44
782455	30	19003FIEST	98.	4	2	10.0	0.39	1.05	1.44
783091	30	70010 F-100 REG CAB LWB	300.	6	1	20.2	0.34	1.10	1.44
783932	30	19055 THUNDERBIRD (60H)	400.	8	2	22.0	0.56	0.78	1.44
783463	570	39015CORONA 4DR SEDAN	133.6	4	2	15.3	0.71	0.74	1.45
783503	30	19025 GRANADA 4DR (54H)	302.	8	2	19.2	0.31	1.14	1.45
783860	30	19019 FAIRMONT 4DR (54B)	302.	8	2	16.0	0.22	1.23	1.45
782445	30	70010 F-100 SWB	302.	8	2	20.2	0.42	1.06	1.48
781741	570	39005COROLLA LIFTBACK SR5	96.9	4	2	13.4	0.79	0.70	1.49
781979	560	70005 COURIER PICKUP	109.6	4	2	17.4	0.70	0.80	1.50
783397	40	33010SUNBIRD SAFARI SW	151.0	4	2	16.0	0.71	0.79	1.50
783249	30	70010F-100 SWB REG.	351.0	8	2	19.2	0.38	1.12	1.51

[illegible]	30	[illegible]	[illegible]	[illegible]	1	1[illegible].0	[illegible]	1.24	1.52
782364	30	70010F-100 LWB	302.	8	2	19.2	0.42	1.09	1.52
783038	40	33055GRAND PRIX	301.	8	2	17.5	0.97	0.57	1.53
783684	40	33015PHOENIX LJ SEDAN	151.0	4	2	21.0	0.73	0.80	1.53
783983	30	70010 F-100 LWB	302.	8	2	19.2	0.49	1.05	1.54
783019	10	85005CJ-7	304.	8	2	14.8	0.67	0.88	1.55
783152	40	33015VENTURA SEDAN	151.	4	2	21.0	0.81	0.74	1.55
783812	40	55025MALIBU COUPE	201.0	5	2	17.5	0.84	0.71	1.55
782254	40	10010CUTLA S"77"	425.	8	FI	24.5	0.71	0.85	1.56
783351	40	55115FLEETSIDE	250.0	6	1	20.0	0.64	0.92	1.56
783836	560	27025 MAZDA RX-3	71.0	2	4	15.1	0.52	1.04	1.56
783840	560	27025 MAZDA RX-3	71.0	2	4	15.1	0.47	1.09	1.57
783996	570	39035CRESSIDA STATION WGN	155.4	6	2	16.2	1.06	0.51	1.57
785116	490	16020COLT WAGON	97.5	4	2	.	0.57	1.00	1.57
782382	120	7005	121.3	4	FI	15.2	0.49	1.10	1.59
782875	120	7015BMW 633CSI	196.	6	FI	16.4	0.77	0.82	1.59
783199	230	18025124 SPORT SPIDER	107.	4	2	11.4	0.50	1.10	1.59
783321	40	12020NOVA CUSTOM SEDAN	305.0	8	2	21.0	0.60	0.99	1.59
784012	230	18015131 STRAFIORI	107.	4	2	12.2	0.74	0.85	1.59
782483	30	19055 THUNDERBIRD	351.	8	2	22.0	0.42	1.19	1.61
783753	40	12040CAPRICE CLASSIC	250.0	6	1	21.0	0.49	1.12	1.62
784071	30	19015 MUSTANG	171.	6	2	13.0	0.28	1.35	1.62
783839	560	27025 MAZDA RX-3	70.0	2	4	15.1	0.42	1.21	1.63
783894	40	12025CAMARO Z28	350.0	8	4	21.	0.77	0.86	1.63
784189	40	12045IMPAL WAGON	350.	8	4	22.0	0.48	1.15	1.63
783012	40	33025LEMANS COUPE	301.	8	2	17.5	0.93	0.71	1.64
783231	40	12010MONZA TOWNE COUPE	151.	4	2	18.5	0.83	0.82	1.65
783822	380	60005PICKUP LONG WHEELBSE	119.1	4	2	11.9	0.35	1.31	1.66
784912	420	34025924	121.	4	FI	16.4	0.61	1.06	1.67
783605	30	24055MARK 5 2DR	400.0	8	2	26.0	0.31	1.37	1.68
782559	230	18015131 STRAFIORI	107.	4	2	12.2	0.74	0.94	1.69
783613	20	32020PLYMOUTH HL29	318.	8	2	19.5	0.86	0.84	1.70
781904	30	19030LTD II	302.	8	2	22.0	0.50	1.21	1.71
782623	30	19015MUSTANG II	302.	8	2	16.5	0.44	1.27	1.71
782647	30	70010F-100 LWB	302.	8	2	20.2	0.67	1.04	1.71
783960	560	27005 MAZDA COSMO	80.0	2	4	16.4	0.61	1.10	1.71
782241	30	19019FAIRMONT (548)	140.0	4	2	16.0	1.12	0.60	1.72
782384	490	16015280-2X	97.5	4	2	15.8	0.37	1.35	1.72
783251	30	24055 MARK V	400.0	8	2	26.0	0.98	0.73	1.72
783472	30	70015 F-100 VAN LWB	300.	6	1	22.1	0.51	1.21	1.72
784753	260	21020HONDA ACCORD CVCC	98.0	4	3	13.2	0.62	1.11	1.72
781636	30	70010 F-100 LWB SC	351.	8	2	14.2	0.51	1.21	1.73
782383	570	39010COROLLA ST WAGON	96.9	4	2	12.4	1.17	0.56	1.73
783379	570	94010HILUX CAB & CHASSIS	133.6	4	2	16.0	1.33	0.40	1.73
784567	30	70010F-100 SUP SC	400.0	8	2	19.5	0.40	1.33	1.73
781369	10	51005DJ-5F	232.0	6	1	11.0	0.57	1.17	1.74
781457	30	19015 MUSTANG (60F)	171.0	6	2	13.0	0.30	1.45	1.74
782135	30	24020 MONARCH	302.	8	2	19.2	0.74	1.01	1.76
782270	30	19045 FORD	351.	8	2	24.2	0.35	1.41	1.76
783136	20	65005B1 VAN 109"WB	315.0	8	2	22.1	0.47	1.29	1.76
783556	20	65005B1 VAN 109"WB	318.0	8	2	22.1	0.49	1.27	1.76
783774	380	60005PICKUP SSP(COMMENTS)	119.1	4	2	17.2	0.50	1.27	1.76
782364	30	19025GRANADA 4DR (548)	250.	6	1	19.2	0.25	1.52	1.77
782580	530	40012TR-8	215.	8	2	14.5	0.51	1.25	1.77
783074	30	19015 MUSTANG II	302.0	8	2	16.5	0.36	1.41	1.77
783695	20	65010DODGE 01 (131" WB)	318.	8	2	18.0	0.57	1.20	1.77
781024	10	85005JEEP CJ5	258.	6	1	15.5	0.44	1.35	1.79
782012	30	19030LTD II	302.	8	2	22.0	0.58	1.20	1.79
782447	30	70010 F-100 LWB	302.	8	2	19.2	0.50	1.29	1.79
783409	420	34010911SC	183.	6	FI	21.	0.58	1.21	1.79
783619	20	32030PLYMOUTH RC41	225.	6	2	25.5	1.15	0.64	1.79
784608	420	34025924	121.	4	FI	16.4	0.61	1.21	1.81
781522	660	38005A66L	97.0	4	2	11.9	0.39	1.42	1.82
782578	530	40012TR-8	215.	8	2	14.5	0.82	0.99	1.82
781383	430	35005LE CAR GTL	78.7	4	2	10.0	0.34	1.49	1.83
782761	200	28020230	141.	4	1	21.1	0.92	0.91	1.83

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781332	30	24020 FORD CH 2-DR.	250.0	6	1	14.2	0.52	1.31	1.84
784322	40	55020CHEVY VAN	305.0	8	2	22.0	1.23	0.61	1.84
782326	30	70010 F-100 SWB REG CAB	351.	8	2	19.5	0.53	1.31	1.85
783015	590	97005BUS STATION WAGON 22	121.	4	FI	14.6	1.31	0.54	1.85
784187	40	55015FLEETSIDE	305.0	8	2	20.0	0.69	1.15	1.85
782142	30	19045FORD	302.	8	2	24.2	0.42	1.43	1.86
782274	40	8030LESABRE CUSTOM SEDAN	350.	8	4	25.5	0.80	1.07	1.86
784590	230	18005128 3 1300	78.7	4	2	12.5	0.62	1.24	1.86
781402	30	19015 MUSTANG (60F)	171.0	6	2	13.0	0.35	1.52	1.87
782705	440	36005SILVER SHADOW II	412.	8	2	22.5	0.50	1.38	1.87
784363	40	33020TRANS AM	400.0	8	4	21.0	1.06	0.81	1.87
781760.	30	70015E-100 SWB VAN	351.	8	2	22.1	0.51	1.37	1.88
783768	380	15005B210 2 DR SEDAN	1397.	4	2	11.6	0.66	1.22	1.88
785148	20	65005B1 VA 109"WB	360.	8	2	22.1	0.96	0.92	1.88
783046	380	15020KHLAIDEV 510 COUPE	119.1	4	2	13.2	0.45	1.44	1.89
784889	10	2010PACER SEDAN	258.	6	1	20.0	0.92	0.98	1.89
785207	490	16020COLT WAGON	97.5	4	2	.	0.79	1.10	1.89
780200	30	19003 FIESTA	98.	4	2	10.	0.92	0.98	1.90
782543	40	12020NOVA SEDAN	250.	6	1	21.	0.45	1.45	1.90
784032	30	24022 VERSAILLES	302.	8	2	19.2	0.24	1.66	1.90
781637	640	5015AUDI 5000	131.	5	FI	8.0	1.12	0.79	1.91
782930	20	32025PLYMOUTH HL45	318.	8	2	19.5	1.29	0.62	1.91
783847	40	12010MONZA TOWNE COUPE	151.	4	2	18.5	1.15	0.76	1.91
784271	30	70025RANCHERO	351.0	8	2	26.0	1.04	0.67	1.91
785415	30	19003FIESTA	95.	4	2	10.0	0.85	1.08	1.92
782220	30	19045 FORD 4DR (53H)	400.	8	2	24.2	0.73	1.20	1.93
782230	490	32015ZP-24	97.5	4	2	13.2	0.64	1.31	1.94
783197	230	18025124 SPORT	107.	4	2	11.4	0.61	1.34	1.95
783394	20	16045PLYMOUTH HL45	318.	8	2	19.5	1.00	0.94	1.95
783504	40	12025CAMARO Z28	350.0	8	4	21.	0.95	1.00	1.95
783759	40	55015STEPSIDE	250.0	6	1	16.0	0.74	1.21	1.95
782052	570	39010COROLLA STATION WGN	96.9	4	2	12.4	1.08	0.84	1.96
782770	20	32025PLYMOUTH HL45	318.	8	2	19.5	1.29	0.66	1.96
784027	20	65005DODGE B1 (109" WB)	225.	6	2	27.0	1.03	0.93	1.96
781993	30	19003 FIESTA	95.	4	2	10.0	0.43	1.56	1.99
782895	380	15035WHLDB10TEV 810 WAGON	146.0	6	FI	14.5	0.91	1.08	1.99
785240	90	01005ALFETTA COUPE-116.15	119.7	4	FI	13.2	1.28	0.72	1.99
781899	30	24005 MONTE CARLO (64H)	140.	4	2	13.	1.15	0.86	2.00
782722	20	65010DODGE D1 (131" WB)	318.	8	2	18.0	0.87	1.13	2.00
784891	40	80005FLEETSIDE	350.	8	4	20.0	0.99	1.02	2.01
782660	330	15040HLS30EU 2807	168.0	6	FI	17.2	1.34	0.68	2.02
784660	40	55025MALIBU COUPE	200.0	6	2	17.5	1.44	0.58	2.02
783962	560	27035 MAZDA RX-4 WAGON	80.0	2	4	17.7	0.78	1.26	2.04
784398	20	32030DODGE WL41	225.	6	2	25.5	0.63	1.41	2.04
785366	20	13020PLYMOUTH PM41	360.0	8	2	26.5	0.82	1.22	2.04
782294	20	65005B1 VAN 109 WB	318.0	8	2	22.1	1.03	1.02	2.05
783416	10	2040MATADOR WAGON	360.	8	2	21.0	0.54	1.51	2.05
784316	40	08022MALIBU COUPE	305.0	8	4	17.5	0.92	1.13	2.05
782659	40	8005SKYLARK	231.	6	2	21.0	1.24	0.81	2.06
782675	20	32020PLYMOUTH HL29	225.	6	1	18.0	1.17	0.88	2.06
783215	570	94020LAND CRUISER WG 2/4	257.9	6	2	21.7	1.17	0.88	2.06
784098	560	27025 MAZDA RX-4	80.0	2	4	16.4	0.69	1.38	2.06
782350	20	65005DODGE B1 (109" WB)	225.	6	2	22.1	0.94	1.12	2.07
782565	230	18005128 SEDAN	78.7	4	2	9.5	0.87	1.20	2.07
783273	20	16045PLYMOUTH HL45	318.	8	2	19.5	1.20	0.89	2.09
784109	40	55015FLEETSIDE	350.0	8	4	16.0	0.71	1.38	2.09
784130	30	24020 MONARCH 4DR (54H)	302.	8	2	19.2	0.11	1.97	2.09
784374	10	2010PACER SEDAN	258.	6	1	20.0	0.85	1.24	2.09
784785	490	32015ARROW	121.7	4	2	13.2	0.79	1.30	2.09
782308	490	320403H-29	97.5	4	2	15.8	0.56	1.56	2.12
784249	30	70010F-100 SUB SC	400.0	8	2	19.5	0.36	1.76	2.12
781595	40	29040ADO BROUGHAM COUPE	403.0	8	4	26.0	0.48	1.65	2.13
783160	30	19021FAIRMONT 4DR	302.	8	2	16.	1.18	0.95	2.14
783367	380	15040GHLS3 AUV 2807 2+2	168.0	6	FI	17.2	1.15	0.98	2.14
783744	10	85005CJ-7	304.	8	2	14.8	1.29	0.85	2.14

781274	290	81152 ROOK COUPE	117.9	4	2	13.7	0.32	1.34	2.15
782571	20	65005R1 VAN 109 WB	318.0	8	2	22.1	1.22	0.92	2.15
782903	380	15020HLATUPAN 510 SEDAN	119.1		2	13.2	0.76	1.39	2.15
785186	90	010102000 SPIDER (115.41)	119.7	4	FI	12.2	0.79	1.37	2.16
783317	40	33020TRANS AM	400.0	8	4	21.0	1.13	1.04	2.17
783319	40	55020SPORTVAN	351.0	8	4	22.0	1.11	1.05	2.17
783917	380	15015F10 SPORT WAGON	1397.	4	2	10.6	0.48	1.68	2.17
781812	40	12050MONTE CARLO SPORT	231.	6	2	17.5	0.71	1.46	2.18
783361	20	65010D1 TRUCK 115"WB	318.0	8	2	18.0	0.50	1.68	2.18
782366	30	70010 F-100 LWB	302.	8	2	19.2	0.61	1.59	2.20
782563	230	18005128 3P 1300	78.7	4	2	12.5	0.56	1.65	2.20
783347	40	33055MALIBU COUPE	305.0	8	2	15.0	1.11	1.09	2.20
783688	40	12025CAMARO Z28	350.0	8	4	21.	1.30	0.90	2.20
784120	260	21020HONDA ACCORD CVCC	98.0	4	3	13.2	0.44	1.77	2.20
784582	20	91005DODGE B1 (109" WB)	318.	8	2	36.0	0.89	1.31	2.20
784412	20	32030PLYMOUTH RC41	225.	6	2	25.5	1.01	1.20	2.21
783626	40	33025GRAND AM SEDAN	301.0	8	4	17.5	1.45	0.78	2.22
784118	20	32020PLYMOUTH HL41	225.	6	1	18.0	0.86	1.36	2.22
782347	20	32030DODGE WH41	225.	6	1	25.5	1.48	0.75	2.23
783693	20	65010DODGE D1 (131" WB)	225.	6	2	18.0	0.57	1.68	2.24
783706	30	24055 MARK V 2-DR (65D)	460.	8	4	26.0	0.65	1.59	2.24
784007	30	24055 MARK V 2-DR (65D)	460.	8	4	25.0	0.71	1.54	2.24
783650	230	18030LANCIA BETA	107.	4	2	12.5	0.74	1.51	2.25
781981	560	70005COURIER PICKUP	140.0	4	2	17.4	0.55	1.71	2.26
781743	570	39020CORONA ST WAGON	133.6	4	2	15.5	1.11	1.15	2.27
782921	40	8005SKYLARK	231.	6	2	21.0	1.62	0.64	2.27
784112	40	55015FLEETSIDE	305.0	8	2	16.0	0.74	1.54	2.27
784430	20	32030DODGE WL41	225.	6	2	25.5	0.88	1.39	2.27
782017	640	5015AUDI 5000	131.	5	FI	8.0	1.38	0.91	2.28
783031	30	70010 F-100 SUPERCAB LWB	300.	6	1	19.5	0.71	1.57	2.28
783245	20	65010D1 TRK 131"WB	318.0	8	2	20.0	0.88	1.40	2.28
783916	230	18040X1/9	78.7	4	2	12.2	0.54	1.74	2.28
784789	490	32015 ARROW	121.7	4	2	13.2	0.89	1.39	2.28
784826	10	2005GREMLIN	258.	6	1	21.	0.97	1.31	2.28
784439	40	55015SUBURBAN	350.	8	4	31.0	0.99	1.31	2.30
784793	490	16020COLT WAGON	155.9	4	2	13.2	0.77	1.53	2.30
781947	640	5015AUDI 5000	131.	5	FI	6.4	1.01	1.30	2.31
783699	20	65005DODGE B1 (109" WB)	225.	6	2	22.1	1.49	0.83	2.32
784243	20	32030DODGE WK41	440.	8	4	20.5	0.72	1.60	2.32
784376	10	2005GREMLIN	258.	6	1	21.0	1.02	1.30	2.32
783335	10	85005CJ-7	258.	6	1	14.8	1.66	0.67	2.33
781823	20	32030PLYMOUTH RC41	225.	6	1	25.4	1.17	1.17	2.34
781826	30	65005E-100 SWB VAN	351.	8	2	18.0	0.54	1.80	2.34
782010	20	65005DODGE B1	318.	8	4	22.1	0.60	1.74	2.34
782582	10	02020HORNET WAGON	304.	8	2	22.	1.28	1.05	2.34
783715	40	8030LESABRE CUSTOM CUOPE	231.0	6	4	21.0	1.14	1.20	2.34
781209	40	33020LA	403.0	8	4	21.0	1.00	1.37	2.37
783239	30	19015 MUSTANG	302.	8	2	16.5	0.27	2.09	2.37
781645	560	70005COURIER PICKUP	109.6	4	2	17.4	0.48	1.89	2.38
782784	40	12040CAPRICE CLASSIC SED	250.	6	1	21.0	1.20	1.18	2.38
783169	30	19050FORD S.W.(71H)	400.	8	2	21.0	0.74	1.64	2.38
784455	30	19015 MUSTANG II 60H	171.	6	2	13.	0.22	2.16	2.38
782457	40	12005CHEVETTE	1600.	4	1	13.0	1.41	0.98	2.39
783045	590	97005BUS STATION WAGON 22	120.	4	FI	14.6	2.12	0.27	2.39
783314	40	12040CAPRICE CLASSIC SED	250.	6	1	21.0	0.98	1.42	2.40
783884	30	19025 GRANADA 2DR (66H)	302.	8	2	19.2	0.42	1.99	2.40
784005	40	8022CENTURY SPECIAL CPE	231.0	6	4	17.5	1.32	1.08	2.40
781641	30	70015E-100 SWB VAN	351.	8	2	18.0	0.32	2.09	2.41
782694	10	02025HORNET WAGON	258.	6	1	22.	1.46	0.95	2.41
783878	40	33020TRANS AM	403.0	8	4	21.0	1.11	1.30	2.41
781859	30	19003 FIESTA	98.	4	2	10.0	0.34	2.08	2.42
782015	30	70015E-100 LWB VAN	351.	8	2	22.1	0.77	1.64	2.42
784183	20	91005DODGE B1 (109" WB)	318.	8	2	36.0	1.02	1.40	2.42
780106	30	19003 FIESTA	98.	4	2	10.	1.33	1.11	2.43
784515	40	12025CAMARO Z-28	350.	8	4	21.0	1.36	1.07	2.43
782411	10	02005GREMLIN	121.0	4	2	15.0	1.57	0.88	2.45

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782294	20	91005R109	360.	9	2	36.	1.25	1.21	2.46
783972	10	85005CJ-7	258.	6	1	14.8	1.41	0.65	2.46
783099	230	18005126 SEDAN	78.7	4	2	9.5	0.33	2.14	2.47
781774	560	70005COURIER PICKUP	140.0	4	2	17.4	0.51	1.99	2.50
782138	40	8040ELECTRA 225 COUPE	350.	8	4	25.5	1.31	1.19	2.50
784427	20	32030PLYMOUTH RC41	225.	6	2	25.5	1.26	1.24	2.50
784783	490	16015CHALLENGER	155.9	4	2	15.8	1.04	1.45	2.50
782404	10	02025HORNET WAGON	258.	6	1	22.	0.97	1.56	2.52
784528	20	32030DODGE WL41	225.	6	2	25.5	0.95	1.57	2.52
782649	30	19055 THUNDERBIRD	351.	8	2	22.	1.36	1.18	2.54
783196	30	19019 FAIRMONT 4DR	302.	8	2	16.	0.30	2.24	2.54
784163.	380	60005PICKUP LONG WHEELBAS	119.1	4	2	11.9	0.22	2.33	2.55
782302	490	32015ZL-24	97.5	4	2	13.2	0.67	1.89	2.56
782746	40	33020FORMULA	403.	8	4	21.0	0.98	1.58	2.56
782947	40	12040CAPRICE CLASSIC	250.	6	1	21.0	1.30	1.26	2.56
783780	380	15010F10 HATCHBACK 5SP.	1397.0	4	2	10.6	0.54	2.03	2.56
783084	20	91005B100	361.	8	2	36.	1.22	1.36	2.58
784504	20	32030DODGE WL41	225.	6	2	25.5	1.08	1.50	2.58
783036	40	12055CORVETTE SPORT CP	350.	8	4	23.7	1.04	1.55	2.59
784021	20	16040PLYMOUTH HL45	318.	8	2	19.5	1.42	1.18	2.59
784024	20	65005DODGE B1	225.	6	2	36.0	1.38	1.20	2.59
784154	380	15015F10 SPORT WAGON	1397.	4	2	10.6	0.25	2.34	2.59
784482	40	53005COMMERCIAL CHASSIS	425.0	8	4	25.3	1.03	1.56	2.59
782726	30	70610F-100 REG CAB L-8	300.	6	1	19.2	0.59	2.02	2.60
784135	40	12025CAMARO Z-28	350.0	8	4	21.0	0.53	2.07	2.60
783524	20	32030PLYMOUTH RH41	318.	8	2	25.5	1.46	1.14	2.61
783950	20	13020PLYMOUTH GRAN FURY	360.0	8	4	26.5	1.50	1.11	2.61
784882	20	65005DODGE B1(127" W.B.)	318.	8	4	36.0	1.05	1.56	2.61
784809	20	65005DODGE B1(127" W.B.)	318.	8	4	36.0	1.22	1.41	2.63
782901	380	15030HLGB10AFV 810 SEDAN	146.0	6	FI	15.9	1.57	1.08	2.64
782955	30	70015 E-100 LWB VAN	351.	8	2	16.0	0.71	1.93	2.64
783969	20	16045PLYMOUTH HL45	318.	8	2	19.5	1.61	1.03	2.64
784396	20	32025PLYMOUTH HL45	225.	6	2	19.5	0.83	1.81	2.64
783177	20	65005B1 VAN (109"W.B.)	360.	8	2	22.	1.31	1.34	2.65
783590	40	12005CHEVETTE	1600.	4	1	13.0	1.31	1.35	2.65
784850	20	13020CHRYSLER CL41	400.	8	4	26.5	1.05	1.60	2.65
784097	560	27035 MAZDA RX-4 WAGON	80.0	2	4	17.7	1.05	1.61	2.66
784781	490	16020COLT WAGON	155.9	4	2	13.2	1.10	1.56	2.66
785111	20	65005DODGE B1(127" W.B.)	318.	8	4	36.0	1.19	1.50	2.70
780955	20	16030 PLYMOUTH VOLARE	360.0	8	4	19.5	0.92	1.81	2.72
782828	380	15025WHLA1AV 510 WAGON	119.1	4	2	13.2	0.66	2.06	2.72
783703	20	13020PLYMOUTH PH41	360.	8	2	26.5	1.29	1.43	2.72
781974	20	32025DODGE NM45	225.	6	1	18.0	0.95	1.77	2.73
782953	30	70025 RANCHERO 500	400.0	8	2	26.	1.59	1.13	2.73
784131	20	13015CHRYSLER XS22	360.	8	4	25.5	0.73	2.02	2.74
784535	20	13015CHRYSLER XS22	361.	8	4	25.5	1.08	1.66	2.74
782338	30	24055MARK V SEDAN 653	460.	8	4	26.	0.84	1.91	2.75
783241	20	65010DODGE B1 (115" W.B.)	318.	8	4	18.0	1.11	1.64	2.75
782741	290	LUV-1 SUBSTITUTE FOR LUV2	110.8	4	2	13.2	0.36	2.40	2.76
782874	30	19055 THUNDERBIRD	351.	8	2	22.	1.77	1.01	2.78
783311	20	91005DODGE B1 (109" WB)	318.	8	2	36.0	1.41	1.37	2.78
783490	40	33020FORMULA	400.0	8	4	21.0	1.30	1.50	2.80
785087	20	32035 PLYMOUTH FURY WAGON	360.0	8	2	20.0	1.58	1.23	2.81
785251	20	91005B1 VAN (109"WB)	318.	8	4	36.0	0.81	2.00	2.81
782854	380	15020KHLA1UFV 510 COUPE	119.1	4	2	13.2	0.69	2.12	2.82
783489	40	33020TRANS AM	400.0	8	4	21.0	1.83	0.99	2.82
781611	40	29035REGENCY SEDAN	403.0	8	4	25.5	1.23	1.60	2.83
781644	560	27020 MAZDA GLC	77.6	4	2	10.6	0.34	2.49	2.83
783850	20	16050DODGE WL23	225.	6	2	25.5	1.68	1.16	2.84
783654	420	34030928	273.	8	FI	22.7	0.92	1.93	2.85
784018	20	13020PLYMOUTH GRAN FURY	360.0	8	4	26.5	2.08	0.77	2.85
784149	30	19003 FIESTA	98.	4	2	10.0	0.24	2.61	2.85
784193	40	53005COMMERCIAL CHASSIS	425.0	8	4	25.3	1.37	1.48	2.85
785326	20	91005B1 VAN (109"WB)	318.	8	4	36.0	0.90	1.95	2.85
780881	290	80152DOOR COUPE	110.8	4	2	13.7	1.06	1.81	2.86

7831[illegible]	20	91005DODGE B1 (109" WB)	31[illegible].	8	2	36.0	1.60	1.26	2.86
783680	30	19050STATION WAGON 71H	461.	8	4	21.0	0.56	2.29	2.86
780029	30	19003 FIESTA	98.		2	10.	1.80	1.07	2.87
784107	40	80010RALLY STX	258.0	6	1	22.0	1.08	1.79	2.87
781590	20	32030 PLYMOUTH FURY	440.0	8	4	20.0	0.70	2.16	2.88
783682	30	19050 MERCURY (65H)	460.	8	4	24.2	0.99	1.89	2.88
784023	20	32030PLYMOUTH PC41	225.	6	2	25.5	1.59	1.29	2.88
784585	40	53005COMMERCIAL CHASSIS	425.0	8	4	25.3	1.47	1.41	2.88
782792	20	91005DODGE B1 (109" WB)	318.	8	2	36.0	1.66	1.23	2.89
783591	20	16050PLYMOUTH RH41	318.	8	2	25.5	1.07	1.82	2.89
785040	20	65510DODGE TRUCK 131"WB	360.0	8	4	20.0	1.13	1.76	2.89
781474	20	32025 PLYMOUTH VOLARE	225.0	6	2	19.5	1.28	1.62	2.90
781765	560	27020MAZDA GLC SEDAN	77.6	4	2	10.6	0.55	2.35	2.90
783701	20	16035PLYMOUTH HL45	225.	6	2	19.5	1.30	1.60	2.90
783924	20	16050DODGE WL23	225.	6	2	25.5	1.69	1.20	2.90
783845	40	10010DEVILLE SEDAN	425.0	8	4	25.3	0.85	2.06	2.91
782250	30	19050STATION WAGON 71H	461.	8	4	21.0	0.40	2.52	2.92
783299	10	02025HORNET WAGON	258.	6	1	22.	1.36	1.55	2.92
782763	570	39010COROLLA STATION WGN	96.9	4	2	12.4	1.50	1.44	2.93
784148	30	19003 FIESTA	98.	4	2	10.0	0.42	2.51	2.93
784152	560	27035 MAZDA RX-4 WAGON	80.0	2	4	17.7	0.41	2.52	2.93
782982	40	12005CHEVETTE	1600.	4	1	13.0	1.44	1.50	2.94
783362	30	19003 FIESTA	98.	4	2	10.0	0.36	2.58	2.94
781188	10	02005GREMLIN	121.0	4	2	15.0	1.76	1.19	2.95
782745	30	19003 FIESTA	98.	4	2	10.0	0.35	2.58	2.95
784394	20	16050PLYMOUTH RH41	225.	6	2	25.5	0.96	1.98	2.95
784810	20	32030DODGE XS22	318.	8	4	25.5	0.94	2.00	2.95
781795	560	70005 COURIER PICKUP	140.	4	2	14.7	0.39	2.57	2.96
782417	10	02005GREMLIN	121.0	4	2	15.0	1.76	1.25	3.00
783135	20	13020CHRYSLER CS43	440.	8	4	26.5	1.23	1.77	3.00
784688	20	13015CHRYSLER SS22	400.	8	4	25.5	0.87	2.14	3.01
782407	560	70005COURIER PICKUP	109.6	4	2	17.4	0.65	2.43	3.08
783523	20	91005B1 VAN 109"WB	360.0	8	2	36.0	1.28	1.80	3.08
783761	40	55020CHEVY VAN	305.0	8	2	33.0	1.93	1.15	3.08
784806	20	16050PLYMOUTH RC41	400.	8	4	25.5	0.87	2.20	3.08
782423	30	19019 FAIRMONT	200.	6	1	16.0	0.15	2.94	3.09
781976	20	65005DODGE B1 (127"W.B.)	360.	8	4	36.0	1.35	1.74	3.10
784165	560	27035 MAZDA RX-4 WAGON	80.0	2	4	17.7	0.69	2.42	3.10
785235	470	37005SAAB 99	121.	4	FI	14.5	0.68	2.42	3.10
785344	40	53005COMMERCIAL CHASSIS	425.0	8	4	25.3	1.32	1.78	3.10
781654	20	32025 PLYMOUTH VOLARE	225.0	6	2	19.5	1.44	1.67	3.11
781668	20	32030 DODGE MONACO	225.	6	2	10.2	1.43	1.68	3.11
785265	420	34025924	121.0	4	FI	16.4	0.98	2.13	3.11
782961	40	29035REGENCY SEDAN	403.0	8	4	25.5	1.65	1.48	3.13
783385	20	13020CHRYSLER CS43	440.	8	4	26.5	1.21	1.92	3.13
784364	40	10010DEVILLE COUPE	425.0	8	4	25.3	1.89	1.25	3.14
784428	20	16050DODGE WL23	225.	6	2	25.5	1.47	1.67	3.14
782780	30	19015MUSTANG II	302.	8	2	16.5	1.90	1.25	3.15
783857	10	2020HORNET WAGON	258.	6	2	22.0	1.73	1.42	3.15
783969	40	53005COMMERCIAL CHASSIS	425.0	8	4	25.3	1.44	1.70	3.15
784409	30	70025RANCHERO	351.0	8	2	26.0	2.14	1.01	3.15
783411	420	34030928	273.	8	FI	22.7	1.19	1.99	3.17
781842	20	32020PLYMOUTH HC41	225.0	6	1	19.5	1.49	1.69	3.18
781631	290	80152DOOR COUPE	110.8	4	2	13.7	0.99	2.20	3.19
783378	230	18030LANCIA BETA	107.	4	2	12.5	1.58	1.61	3.19
783766	10	02035MATADOR 4DR	360.	8	2	21.	1.92	1.27	3.19
785146	20	32035 PLYMOUTH FURY WAGON	360.0	8	2	20.0	1.62	1.58	3.20
782885	380	15045HLS10AV 200SX	119.1	4	2	15.9	0.95	2.26	3.21
783601	40	33055MALIBU COUPE	305.0	8	2	15.0	2.24	0.97	3.21
782284	10	2010PACER WAGON	258.	6	2	20.	1.18	2.05	3.23
783383	20	16060XS22	360.0	8	2	25.5	2.07	1.16	3.23
783615	20	32025DODGE NH45	225.	6	1	19.5	1.63	1.59	3.23
784202	10	02005GREMLIN	232.	6	1	21.0	2.11	1.13	3.24
784963	20	16060XS22	360.0	8	2	25.5	1.93	1.34	3.27
781913	40	10010SEDAN DEVILLE	425.	8	4	25.3	1.94	1.37	3.30
783666	40	12055CORVETTE SPORT COUPE	350.0	8	4	23.7	0.96	2.35	3.31

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.33
783658	30	19055 THUNDERBIRD	351.	[illegible]	2	22.	2.34	1.00	3.34
784380	10	02035MATADOR 4DR	360.		2	21.	1.92	1.42	3.34
783726	10	2010PACER WAGON	232.		1	20.0	2.02	1.33	3.35
783892	40	12055CORVETTE SPORT COUPE	350.0	8	4	23.7	1.19	2.16	3.35
784927	590	42010RABBIT BASIC	89.	4	1	10.5	0.29	3.06	3.35
783323	40	80010RALLY STX	350.0	8	4	33.0	1.85	1.51	3.36
783334	10	02035MATADOR 4DR	360.	8	2	21.	2.06	1.30	3.36
784735	10	2005GREMLIN	121.	4	2	13.0	2.32	1.03	3.36
784890	10	2005GREMLIN	121.	4	2	13.0	2.29	1.07	3.36
783519	20	32020PLYMOUTH HL41	225.	6	1	18.0	1.79	1.58	3.37
784155	380	15005B210 HATCHBACK	1397.	4	2	11.4	0.11	3.25	3.37
782272	40	12010MONZA SPORT COUPE	231.	6	2	15.5	0.78	2.61	3.40
775191	20	13005 PLYMOUTH VOLARE	318.	8	2	19.5	1.22	2.19	3.41
784880	10	2005GREMLIN	121.	4	2	13.0	2.13	1.29	3.42
781982	40	10010SEDAN DEVILLE	425.	8	4	25.3	1.93	1.50	3.43
783639	10	2030MATADOR 4DR SEDAN	258.	6	2	25.0	2.09	1.34	3.43
784472	40	8022CENTURY SPECIAL	231.	6	2	17.5	2.17	1.25	3.43
783539	40	55020SPORTVAN	250.0	6	1	33.0	1.18	2.26	3.44
783124	30	19003 FIESTA	98.	4	2	10.0	0.50	2.97	3.47
783297	10	85005CJ-7	258.	6	1	14.8	2.76	0.71	3.47
783492	40	29035NINETY EIGHT REGENCY	403.0	8	4	25.3	1.90	1.57	3.47
784819	10	2005GREMLIN	121.	4	2	13.0	2.15	1.32	3.47
783514	20	16050DODGE WL23	225.	6	2	25.5	2.19	1.36	3.55
784578	40	8022CENTURY SPECIAL	231.	6	2	17.5	2.28	1.27	3.55
781315	20	32030 PLYMOUTH FURY	360.0	8	2	25.4	2.15	1.42	3.57
782984	40	12010MONZA 2+2 SPORT CP	305.	8	2	18.5	0.63	2.94	3.57
781532	30	19010 PINTO S.W. (73B)	171.0	6	2	14.0	0.34	3.23	3.58
783399	40	29035GENCY SEDAN	403.0	8	4	25.5	2.47	1.14	3.61
785134	20	65010DODGE D1 (131"WB)	360.	8	4	20.0	1.79	1.83	3.62
782919	40	29015CUTLASS SUPREME	260.	8	2	17.5	0.49	3.14	3.63
782869	40	29035GENCY SEDAN	403.0	8	4	25.5	2.15	1.50	3.64
783559	20	13020CHRYSLER CS43	440.	8	4	26.5	1.12	2.55	3.67
783082	20	6501OD1 TRK 133"WB	360.0	8	2	18.0	2.24	1.54	3.78
783872	40	55015FLEETSIDE	250.0	6	1	20.0	2.57	1.21	3.78
783002	20	32030PLYMOUTL RC41	225.	6	1	25.5	2.77	1.01	3.79
781414	20	32020 PLYMOUTH VOLARE	225.0	6	1	19.5	1.29	2.51	3.80
784254	10	02035MATADOR 4DR	360.	8	2	21.	2.20	1.62	3.81
784441	40	55020SPORT VAN	400.	8	4	33.0	1.82	1.99	3.81
782618	10	2020HORNET 4DR	258.	6	2	22.0	2.47	1.36	3.83
782410	10	02035MATADOR 4DR	360.	8	2	21.	1.17	2.67	3.84
782422	40	29025DELTA 88 SEDAN	231.	6	2	25.5	2.68	1.16	3.84
783912	10	2010PACER WAGON	232.	6	1	20.0	2.36	1.48	3.84
785206	20	65010DODGE D-1(115"WB)	360.	8	4	20.0	1.29	2.55	3.84
784214	40	10010DEVILLE SEDAN	425.0	8	4	25.3	1.74	2.11	3.85
782318	30	19025GRANADA	302.	8	2	19.2	0.74	3.11	3.86
782732	40	29035GENCY SEDAN	403.0	8	4	25.5	2.40	1.46	3.86
782078	20	32025DODGE NH45	225.	6	1	18.0	1.27	2.59	3.87
783207	40	29010STARFIRE SX	231.	6	2	18.5	1.56	2.32	3.89
781451	20	16050 DODGE MONACO	360.0	8	2	25.4	1.94	1.95	3.90
781359	660	38005AA6L	97.0	4	2	11.9	2.33	1.60	3.93
784111	40	55020CHEVY VAN	305.0	8	2	33.0	2.93	1.01	3.94
785107	20	32030 PLYMOUTH FURY	360.0	8	2	25.4	2.65	1.32	3.96
782406	560	70005COURIER PICKUP	140.	4	2	17.4	0.74	3.25	3.99
782392	20	16060PLYMOUTH PL41	400.	8	4	25.5	1.20	2.81	4.01
784242	20	13020CHRYSLER CS43	440.	8	4	26.5	1.33	2.75	4.08
783460	20	6501OD1 131"WB	225.0	6	2	20.0	2.50	1.59	4.09
784134	40	29015CUTLASS SUPREME	260.	8	2	17.5	0.63	3.51	4.13
783360	590	97005BUS STATION WAGON 22	120.	4	FI	14.6	3.44	0.71	4.15
784669	20	13020CHRYSLER CS43	440.	8	4	26.5	1.54	2.61	4.15
783193	20	32025DODGE HL45	225.	6	2	19.5	2.19	1.97	4.16
782703	10	02035MATADOR 4DR	360.	8	2	21.	2.32	1.86	4.20
784201	10	2020HORNET WAGON	232.	6	1	22.0	3.01	1.21	4.22
785132	20	65010DODGE D1	360.	8	2	20.0	2.44	1.81	4.25
781449	20	32030 PLYMOUTH FURY	225.0	6	1	25.4	0.86	3.43	4.29
783548	10	2010PACER WAGON	232.	6	1	20.0	1.21	3.09	4.30

783306	10	2030MATADOR 4DR SEDAN	[illegible]	8	2	25.0	[illegible]	1.81	4.38
783377	20	32025DODGE HL45	225.	6	2	19.5	2.36	1.53	4.38
785418	40	53005COMMERCIAL CHASSIS	425.0	8	4	25.3	1.37	3.06	4.44
781643	560	70005COURIER PICKUP	140.	4	2	17.4	0.54	3.93	4.46
782462	40	29020CUTLASS S	260.	8	2	18.3	0.34	4.14	4.48
784517	40	08022MALIBU COUPE	305.0	8	4	17.5	3.36	1.12	4.48
785042	20	65010DODGE D1 C/C	360.	8	4	20.0	2.51	2.00	4.51
784153	560	27005 MAZDA COSMO	80.0	2	4	16.4	0.90	3.63	4.53
784281	590	42010RABBIT BASIC	89.	4	1	10.5	0.43	4.10	4.53
784055	20	65010DODGE D1 (131" W.B.)	225.	6	2	20.0	2.46	2.09	4.55
781439	40	8045RA COUPE	403.0	8	4	24.5	3.05	1.55	4.60
781953	640	5015AUDI 5000	131.	5	FI	8.0	1.36	3.26	4.62
783873	40	12005CHEVETTE 2-DOOR	1600.	4	1	13.	1.74	2.93	4.66
783697	20	65010DODGE D1 (131" W.B.)	225.	6	2	20.0	2.85	1.89	4.74
781108	660	39010A67L	97.0	4	2	11.9	2.71	2.05	4.76
783341	10	2020HORNET 4DR	258.	6	2	22.0	2.75	2.01	4.76
784122	40	12055CORVETTE SPORT COUPE	350.	8	4	23.7	0.72	4.04	4.76
781752	20	13005 DODGE ASPEN	360.0	8	2	19.5	3.45	1.33	4.78
784468	40	55015SUBURBAN	454.	8	4	40.0	2.21	2.67	4.88
784052	10	02035MATADOR 4DR	360.	8	2	21.	3.37	1.52	4.89
783646	40	10020FLDORADO	425.0	8	4	27.5	1.77	3.18	4.94
782116	40	12005CHEVETTE	1600.	4	1	13.0	1.32	3.69	5.00
783191	20	65005DODGE F1(127" W.B.)	318.	8	4	36.0	3.09	1.92	5.00
784992	20	32030 PLYMOUTH FURY	360.0	8	2	25.4	3.63	1.40	5.03
783312	20	65005DODGE F1(127" W.B.)	318.	8	4	36.0	3.08	1.97	5.05
783929	20	65010DODGE D1 (131" WB)	360.	8	2	20.0	3.65	1.41	5.06
783521	20	65010DODGE D1 (131" WB)	360.	8	2	20.0	3.58	1.58	5.16
781404	660	39005A67L	97.0	4	2	11.9	2.71	2.46	5.17
782218	20	32020 DODGE ASPEN	225.	6	1	19.5	3.45	1.72	5.17
784140	40	80010RALLY STX	350.0	8	4	33.0	2.30	2.97	5.27
783568	40	10010BROUGHAM	425.0	8	4	25.3	2.04	3.31	5.35
783023	10	02035MATADOR 4DR	360.	8	2	21.	3.63	1.78	5.41
782928	20	65010DODGE D1 (131" W.B.)	225.	6	2	20.0	3.09	2.40	5.49
784996	20	16050 DODGE MONACO	360.0	8	2	25.4	2.84	2.66	5.50
783498	20	65010DODGE D1	360.	8	2	20.0	3.56	1.95	5.51
783914	40	10020FLDORADO	425.0	8	4	27.5	2.84	2.76	5.59
784480	40	10020FLDORADO	425.0	8	4	27.5	2.94	2.76	5.69
783843	40	12005CHEVETTE 2 DR	1600.	4	1	13.0	2.53	3.21	5.73
783662	40	55015STEPSIDE	350.0	8	4	20.0	3.52	2.24	5.76
782058	40	29025DELTA 88 ROYALE	260.	8	2	25.5	1.33	4.46	5.78
784017	20	13020CHRYSLER CS43	440.	8	4	26.5	1.53	4.25	5.79
781819	10	02035MATADOR 4DR	360.	8	2	25.	1.20	4.61	5.81
782766	20	32020PLYMOUTH HL41	225.	6	1	18.0	3.97	1.91	5.89
782621	40	29035Y EIGHT LUXURY CPE	350.0	8	4	25.5	0.93	4.99	5.93
782776	20	65005DODGE F1(127" W.B.)	318.	8	4	35.0	3.40	2.53	5.93
782626	30	19030 LTD II	351.	8	2	22.0	5.05	0.98	6.03
783454	20	13020CHRYSLER CS43	400.	8	4	26.5	5.04	1.21	6.25
782739	30	19019 FAIRMONT	200.	6	1	16.0	0.09	6.17	6.26
783910	10	2005GREMLIN	258.	6	1	21.	2.09	4.24	6.33
782934	30	19015 MUSTANG	302.	8	2	16.5	0.34	6.09	6.44
781289	20	13000 DODGE MONACO	360.0	8	2	26.5	4.96	1.49	6.45
781754	40	29035Y EIGHT LUXURY CPE	350.0	8	4	25.5	0.53	5.93	6.46
783465	20	65005B1 VA (109" W.B.)	360.	8	2	22.	5.56	1.35	6.90
781699	40	29035GENCY SEDAN	403.0	8	4	25.5	1.26	5.67	6.93
782545	40	12040CAPRICE CLASSIC SED	250.	6	1	21.0	0.81	6.16	6.97
784015	20	32030PLYMOUTH RH41	318.	8	4	25.5	5.36	1.68	7.04
781237	40	8045RA COUPE	403.0	8	4	24.5	2.09	5.32	7.41
781131	40	8045RA COUPE	403.0	8	4	24.5	1.91	5.61	7.51
783188	20	65010DODGE D1 C/C	360.	8	4	20.0	1.52	6.24	7.76
783500	10	2005GREMLIN	258.	6	1	21.	2.29	5.48	7.77
783344	10	2005GREMLIN	258.	6	1	21.	2.32	5.60	7.91
783021	10	2010PACER SEDAN	258.	6	1	20.0	1.19	6.74	7.93
781584	30	19019FAIRMONT	200.0	6	1	16.0	0.30	7.82	8.12
783911	10	2010PACER SEDAN	258.	6	1	20.0	1.68	6.51	8.18
781472	20	32020 DODGE ASPEN	225.	6	1	19.5	6.48	2.13	8.61
781673	20	13000 DODGE MONACO	360.0	8	2	26.5	7.41	1.56	8.97

[illegible]	20	[illegible] MONACO	[illegible]	[illegible]	[illegible]	25.4	[illegible]	[illegible]	[illegible]
783809	20	13020CHRYSLER CS43	400.		4	26.5	7.59	1.45	9.04
784484	690	23005UPRACO P121 A	182.8		8	15.4	1.24	8.05	9.29
781666	20	32020 DODGE ASPEN	225.	.	1	19.5	7.67	1.99	9.66
783486	20	6501001 TRUCK 131"WB	360.0	8	4	20.0	1.18	8.48	9.66
781410	20	16050 DODGE MONACO	440.	8	4	20.0	3.38	6.44	9.82
783243	20	6501001 TRUCK 131"WB	360.0	8	4	20.0	1.33	8.64	9.97
783640	40	12005CHEVETTE 2 DR	1600.	4	1	13.0	6.42	3.67	10.09
783464	20	65010DODGE D1 C/C	360.	8	4	20.0	6.77	3.45	10.21
785420	10	2020HORNET 4DR	258.	6	2	22.0	9.94	3.04	12.98
785517	10	2020HORNET 4DR	258.	6	2	22.0	9.87	3.83	13.70
782836	590	97005BUS STATION WAGON 22	120.	4	FI	14.6	16.68	0.54	17.22
781908	640	5015AUDI 5000	131.	5	FI	8.0	8.76	12.16	20.92

[illegible]/10

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HISTOGRAM  TOTAL EMISSION IN .10 INCREMENTS

MIDPOINT     COUNT FOR A.TOTALOSS   (EACH X= 1)

 0.            0 *
 .10000        0 *
    000        0 *
    100        1 *
    000        0 *
 .50000        1 *X
 .60000        6 *XXXXXX
 .70000        7 *XXXXXXX
 .80000       13 *XXXXXXXXXXXXX
 .90000        7 *XXXXXXX
 1.0000       13 *XXXXXXXXXXXXX
 1.1000       13 *XXXXXXXXXXXXX
 1.2000       20 *XXXXXXXXXXXXXXXXXXXX
 1.3000       17 *XXXXXXXXXXXXXXXXX
 1.4000       17 *XXXXXXXXXXXXXXXXX
 1.5000       13 *XXXXXXXXXXXXX
 1.6000       21 *XXXXXXXXXXXXXXXXXXXXX
 1.7000       21 *XXXXXXXXXXXXXXXXXXXXX
 1.8000       22 *XXXXXXXXXXXXXXXXXXXXXX
 1.9000       25 *XXXXXXXXXXXXXXXXXXXXXXXXX
 2.0000       18 *XXXXXXXXXXXXXXXXXX
 2.1000       20 *XXXXXXXXXXXXXXXXXXXX
 2.2000       22 *XXXXXXXXXXXXXXXXXXXXXX
 2.3000       24 *XXXXXXXXXXXXXXXXXXXXXXXX
 2.4000       19 *XXXXXXXXXXXXXXXXXXX
 2.5000       13 *XXXXXXXXXXXXX
 2.6000       22 *XXXXXXXXXXXXXXXXXXXXXX
 2.7000       13 *XXXXXXXXXXXXX
 2.8000       13 *XXXXXXXXXXXXX
 2.9000       29 *XXXXXXXXXXXXXXXXXXXXXXXXXXXXX
 3.0000        8 *XXXXXXXX
 3.1000       16 *XXXXXXXXXXXXXXXX
 3.2000       16 *XXXXXXXXXXXXXXXX
 3.3000        6 *XXXXXX
 3.4000       16 *XXXXXXXXXXXXXXXX
 3.5000        4 *XXXX
 3.6000        9 *XXXXXXXXX
 3.7000        1 *X
 3.8000       11 *XXXXXXXXXXX
 3.9000        8 *XXXXXXXX
 4.0000        3 *XXX
 4.1000        3 *XXX
 4.2000        5 *XXXXX
    000        3 *XXX
     00        3 *XXX
     00        6 *XXXXXX
 4.6000        3 *XXX
 4.7000        2 *XX
 4.8000        4 *XXXX
 4.9000        3 *XXX
 5.0000        3 *XXX
 5.1000        2 *XX
 5.2000        3 *XXX
 5.3000        1 *X
 5.4000        2 *XX
 5.5000        3 *XXX
 5.6000        1 *X
 5.7000        2 *XX
 5.8000        4 *XXXX
 5.9000        3 *XXX
 6.0000        1 *X
 6.1000        0 *
 6.2000        0 *
 6.3000        3 *XXX
 6.4000        1 *X
 6.5000        2 *XX
 6.6000        0 *
 6.7000        0 *
 6.8000        0 *
 6.9000        2 *XX
 7.0000        2 *XX
 7.1000        0 *
 7.2000        0 *
 7.3000        0 *
 7.4000        1 *X
 7.5000        1 *X
 7.6000        0 *
 7.7000        0 *
 7.8000        2 *XX
 7.9000        2 *XX
 8.0000        0 *
 8.1000        1 *X
 8.2000        1 *X
 8.3000        0 *
 8 4000        0 *
     00        0 *
     00        1 *X
    000        0 *
 8.8000        0 *
 8.9000        0 *
 9.0000        3 *XXX
 9.1000        0 *
 9.2000        0 *
 9.3000        1 *X
 9.4000        0 *
```

Figure 1. - Results of EPA Conducted Evaporative Emission Tests on 1978 Model Year Certification Data Vehicles.

Note: 10 highest values are not shown.

References

(1) "Technical Feasibility of a 2.0 g/test SHED Evaporative Emission Standard for Light Duty Vehicles and Trucks," Issue paper by Michael W. Leiferman, U.S. EPA, Ann Arbor, Michigan, June 1976.

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

(3) "Progress Report on Chrysler's Efforts to Meet the 1977 and 1978 Federal Emission Standards for HC, CO and NOx," Vol III, Chrysler Corporation, December 1975.

(4) "A Study of Methods for Reducing Evaporative Background Hydrocarbon Emissions from New Vehicles", Technical Support Report for Regulatory Action, OMSAPC, U.S. EPA, Ann Arbor, Michigan, October 1976.

(5) "Accelerated Decay of Non-fuel Evaporative Emissions", Automotive Environmental Systems, Inc., EPA Contract No. 68-03-2413, Report EPA-460/3-76-026, August 1976.

(6) "Lead time Requirements for an Evaporative Emission Standard of 2.0 g/test for Light Duty Vehicles and Trucks," Issue paper by Michael W. Leiferman, U.S. EPA, Ann Arbor, Michigan, June 1976, (Revision 11/77).

(7) EPA Memorandum to the File entitled, "Meeting with General Motors Concerning Their Development Efforts to Meet a 2.0 g/test Evaporative Emission Standard", August 11, 1977.

(8) EPA Memorandum to the File entitled, "Meeting with General Motors Concerning Lead Time Necessary for Implementation of a 2.0 g/test Evaporative Emission Standard for Light Duty Vehicles and Light Duty Trucks", November, 1977.

(9) EPA Memorandum to the File entitled, "Meeting with General Motors (GM) Concerning GM's Progress in Developing Light-Duty Truck Evaporative Control Systems for the Proposed 2.0 g/test Standard", February, 1978.

(10) "Public Hearing on California Waiver Request", Hearing Record Vol. II, pgs. 213-333, May 17, 1977.

Issue - "Cost of a 2.0 g/test Standard"

The following comments were received regarding the costs involved in meeting a 2.0 g/test standard.

A. Summary of Comments

AMC - American Motors cannot respond to the specific question regarding lead time and component cost per vehicle for the 2 g/test, 1979 proposed standard, as we are still in the process of evaluating and developing probable 1977 and 1978 systems.

Chrysler - Assuming a one gram background subtractive factor, the retail price increase per light-duty vehicle is estimated at $50.00 over the 1977 models.

Council on Wage and Price Stability - There is some disagreement regarding the increased price that will result from the 2 g/test standard. EPA estimates the cost at $11, but one manufacturer (Chrysler) gave the Council an estimate of $50. The Council urges that EPA resolve this cost issue before a decision is rendered on the 2.0 g/test standard.

Department of Commerce - The draft environmental impact statement estimates that the retail "sticker" price per vehicle will increase an average of $11.00. However, Chrysler estimates the price increase at $50.00 per vehicle.

"Although we do not wish to imply that the industrial estimate is necessaily preferable to the EPA estimate, we do feel strongly that such statements (along with others from various segments of the industry) should be carefully considered in discussing the economic impact of the proposed regulations."

IH - IH does not have sufficient information and experience to attempt a cost estimate.

Nissan - Since the current production fuel injection system will probably require no modification, there would be no additional retail cost for these vehicles. In the case of carbureted vehicles, we are unable to establish costs because we do not know what equipment will be required. The following is the retail cost increment only for the devices we used in our experimental work.

Retail cost increment (per/vehicle - 1977 model base)

Auxiliary cooling fan for carburetor	$16.90
Delay timer	$ 5.05
Air inlet shut-off valve	$ 3.40
Carburetor external vent	$ 4.15
Increased Canister capacity	$ 1.80
Total	$31.30

Assumption: Current price level
1 U.S. dollar = 304 Yen

Toyota - "Though a precise cost estimate cannot be made, the price increase per vehicle would be about 18 to 23 dollars over the cost of the current system, if modifications of the carburetor and/or canister are made in order to meet the proposed 2 g/test standard."

B. Discussion

Three vehicle manufacturers gave cost estimates for control systems which would allow current production vehicles to meet a 2.0 g/test standard. The estimated increases in vehicle retail price were $50.00, $31.30 and $18-23 for Chrysler, Nissan and Toyota, respectfully.

Chrysler stated that the design changes which would be needed to meet a 2 g/test standard would be at least the following:

1. Vent carburetor bowl to the charcoal canister
2. Add two-way vent (mechanical or solenoid operation) to carburetor
3. Increase vapor storage capacity by 200%
4. Improve "O" ring shaft seals (fluorosilicone)
5. Provide heated air purge for canister
6. Add activated charcoal inner element to air cleaner
7. Relocate fuel tanks on some models away from exhaust system (with rear underbody modifications)
8. Heat shielding between exhaust pipe and/or resonator and fuel tank.
9. Provide carburetor blower fan with thermal switch
10. Provide vapor tight air cleaner door
11. Add carburetor thermal isolation
12. Recertify fuel system revisions to MVSS301 requirements

Some of the modifications listed above are redundant. For example, if modification 2 were done, the internal carburetor vent would be closed when the engine is not running and bowl vapors would be prevented from going into the air cleaner. In this case modifications 6 and 10 would not be required. Or if modification 10 were done, modifications 2 and 6 would not be required. Also modification 3 and 6 appear redundant. Modification 6 increases vapor storage capacity which is covered by modification 3.

It is also extremely doubtful if modifications 3 and 9 listed above are both needed. Increasing the vapor storage capacity by 200% should easily handle the vapors which are currently generated. In a vehicle evaporative study conducted by Exxon Research and Engineering [1], a Chrysler New Yorker with 440 engine was modified to reduce evaporative emissions. On this vehicle the activated carbon vapor storage capacity was increased 100%, and a barrier in the air cleaner was installed to somewhat increase the vapor storage capacity of the air cleaner. With this increase in vapor storage capacity, the vehicle emitted an average of 1.9 g/test, without any carburetor cooling or carburetor modifications. So a 200% increase in vapor storage capacity appears to be more than adequate, even without a cooling fan.

The Nissan estimate of $31.30 is composed mainly of the cost for the auxiliary cooling fan. As in the case of the Chrysler vehicle, if the vapor storage capacity is sufficient, this cooling fan should not be necessary. However, we do not have any test data for modifications on Nissan vehicles.

The previously referenced study by Exxon has produced substantial information on the types and costs of modifications which are necessary to reduce total SHED evaporative emissions from current production vehicles to levels below 2.0 g/test.[1] Six vehicles were modified in this test program, and each of the six vehicles averaged less than 2.0 g/test of total evaporative emissions (including vehicle background) at completion of the study. Exxon also estimated the cost of each of the modifications performed. These modifications and the cost of each are summarized in Table I. As shown, the cost per vehicle ranged from $2.00 for the Ford vehicle to $25 for the Mazda. The costs listed are twice the cost to the manufacturer. This was assumed to be representative of the increase in vehicle retail cost for these modifications. More details pertaining to these modifications, costs and the associated emission levels are contained in references (1) and (2).

Although most manufacturers did not provide cost information on control systems needed to meet a 2.0 g/test standard, all three of the largest U.S. manufacturers did supply information on systems which had been tested and which gave test results of less than 2.0 g/test. Using

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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, June 1976.

(2) "Cost Effectiveness of a 2 g/test SHED Evaporative Standard for Light Duty Vehicles and Trucks," Issue paper by Michael W. Leiferman, U.S. EPA, Ann Arbor, Michigan, June 1976.

Table I. Summary of Vehicle Modifications and Costs in Achieving a 2.0 g/test Level (EPA Contract No. 68-03-2172)

Vehicle	Modifications		Cost, $
'75 Ford	Canister replacement		1.00
	Seal carburetor leak		0.30
	Barrier in air cleaner		0.20
	Air cleaner sealing		0.30
	Canister bottom cap		0.20
		Total	2.00
'75 Pontiac	Bowl vent to canister		0.50
	Seal carburetor leak		0.30
	Air cleaner sealing		.30
	Canister replacement with PCV purge		1.20
		Total	2.30
'75 Chrysler	Canister replacement		4.00
	Canister bottom caps		0.40
	Bowl vent to canister		0.50
	Barrier in air cleaner		0.20
	Seal carburetor leak		0.30
	Air cleaner sealing		0.30
		Total	5.70
'74 Hornet	Seal carburetor leak		0.30
	Bowl vent to canister		0.50
	Air cleaner sealing		0.30
	Canister replacement with PCV purge		1.00
	Canister bottom cap		0.20
	Barrier in air cleaner		0.20
		Total	2.50
'74 Mazda	2 bowl vents to canister		1.00
	Canister installation with PCV purge		7.00
	Underhood ventilating fan		17.00
	Canister bottom cap		0.20
		Total	25.20
'74 Volvo	Canister replacement		1.00
	Heat shield between tank and muffler		1.00
		Total	2.00

Table II. Estimated Increase in Vehicle Retail Price for Manufacturer Designed and Tested Systems Which Have Yielded Evaporative Losses Less Than 2.0 g/test

Vehicle No.	Vehicle Make	Modification	Cost, $
1	Oldsmobile	Dry canister (PCV purged)	0.60
		Sealed door in air cleaner snorkel	3.40(1)
		Bowl vented to canister	0.50
		Total	4.50
2	Chevelle	Vapor purge valve (PCV purged)	0.60
		Bowl vented to canister	0.50
		Internal vent closed (2-way bowl switch)	4.00(1)
		Total	5.10
3	Chrysler	2-way carburetor bowl vent switch	4.00
4	Chrysler	Bowl vented to canister.	0.50
5 & 6	Ford	Bowl vent valve	3.00
		Enlarged canister	3.00
		PCV purged canister	0.60
		Auxiliary canister	3.00
		Electronic air cleaner door	3.40
		New gas cap	0.25
		Total	13.25 (15.00)(2)
7	Oldsmobile	Manually operated carb. bowl switch	3.00
8	Oldsmobile	Vacuum operated carb. bowl switch	3.00
9	Oldsmobile	Bowl vent to canister	0.50
		Door in air cleaner snorkel	3.40
		Total	3.90
10	Oldsmobile	Manually operated carb. bowl switch	3.00

(1) From manufacturers' comments on "Proposed Evaporative Emission Regulations for Light Duty Vehicles and Trucks", January 13, 1976.

(2) Ford's estimate for this system submitted to the EPA on February 27, 1976.

the costs of modifications determined by the Exxon study, it is possible to estimate the increase in vehicle retail price for these manufacturer developed and tested systems. This has been done in reference (2) and the vehicles, modifications and costs are listed in Table II.

For the Ford vehicles in Table II, the control system is one developed to meet a 6.0 g/test standard. Ford has stated the cost of this system is $15.00, which agrees quite well with the cost of $13.25 which was obtained by summing the estimated costs of the major individual components. As listed in the above table, the costs for the Chrysler and GM modifications ranged from $0.50 to $5.10 per vehicle.

C. Summary and Conclusion

The increase in vehicle retail price estimated by Chrysler ($50) was much higher than what will be necessary to control SHED evaporative emissions to 2.0 g/test. Tests have been conducted on a vehicle equipped with the engine (440 CID) which this manufacturer indicated is their most difficult to control.[3] The SHED evaporative emissions from this vehicle (including vehicle background) were controlled to an average level of 1.9 g/test for an estimated retail price increase of $6. It is also believed that more than the necessary amount of equipment has been included in the estimated price from Nissan; however, test information on modifications to Nissan vehicles is not available.

In a test program conducted by Exxon Research and Engineering Company, six production vehicles were modified to give total SHED evaporative emission levels of below 2.0 g/test. From this work the estimated U.S. sales weighted increase in vehicle retail price is $3 over current production vehicles.[4] Based on the estimated costs of manufacturer developed and tested systems which have given SHED evaporative results of less than 2.0 g/test, the U.S. sales weighted increase in vehicle retail price is $7 over current production vehicles. It is expected that the actual increase in retail price of current production vehicles due to implementation of the 2.0 g/test standard will be between these two values, i.e., between $3 and $7 per vehicle.

From data gathered in the Exxon Study, the U.S. sales weighted increase in vehicle retail price to meet a 6.0 g/test evaporative standard has been estimated.[2] This cost was $2 per vehicle. Considering the cost information in the above paragraph, the estimated U.S. sales weighted increase in retail price to go from a 6.0 g/test standard to a 2.0 g/test standard is between $1 and $5 per vehicle.

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(3) Chrysler Corporation comments to "Proposed Evaporative Emission Regulations," published in Federal Register 41 FR 2022 <u>et seg</u> on Jan. 13, 1976, Feb. 27, 1976.

(4) Based on sales data in "Automotive News Almanac, 1975," and "Automotive News, Mar. 22, 1976."

Issue Paper

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

June 1976

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Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Office of Air and Waste Management
U. S. Environmental Protection Agency

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

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	Total, g 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: No. of Tests	Average Diurnal	Average H. Soak	Total: Range	Total: Average	Exhaust Emissions, g/mi[1]: 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

(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.

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 (c) Bottom on each canister (d) Barrier at base of snorkel (e) Accel. pump shaft leak sealed	1.9 2.0	

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	

Attachment 4

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	

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)			
		HC	CO	NOx
EPA		.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%

Issue Paper

Lead Time Requirement for an Evaporative Emission Standard of 2.0 g/test for Light Duty Vehicles and Trucks

June 1976
(Revision 11/77)

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Standards Development and Support Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Office of Air and Waste Management
U.S. Environmental Protection Agency

Lead Time Requirement for an Evaporative Emission Standard of 2.0 g/test for Light-Duty Vehicles and Trucks

1. Statement of the Problem

Is the implementation of a nationwide 2.0 g/test evaporative emission standard for light duty vehicles and trucks feasible for the 1980 model year?

2. Facts Bearing on the Problem

a. In response to California's request for waiver with respect to 1977 evaporative emissions, several automotive manufacturers submitted information in regards to lead time requirements for a 6.0 g/test standard. Information submitted by GM is contained in the Appendix as Attachment 1, and information submitted by Ford is contained as Attachments 2 and 3 of the Appendix. This information, along with lead time considerations submitted by Chrysler and AMC, is summarized and presented in Table I. Major events in the vehicle certification schedule are also indicated. Table I has been constructed with the assumption that an evaporative standard will be implemented with the 1980 model year. Lead time requirements are then based relative to start of 1980 model year engine production.

b. In their comments to the evaporative NPRM, manufacturers did not submit detailed lead time information in regards to implementation of a 2.0 g/test standard.

3. Discussion

a. Table I compares the lead time requirements of the four largest U.S. manufacturers in regards to a SHED evaporative standard implementation for the 1980 model year. The manufacturers agree quite closely in regards to the tooling time needed for making carburetor vent changes. This lead time, which varies from 10 to 12 months, includes both internal and external vent modifications. Beyond the carburetor vent changes, Ford indicated in May 1975 (Attachment 2 of the Appendix), that they need to make major changes to their model 2700 carburetor. These tooling changes have already been made for compliance with the 6.0 g/test standard. It is anticipated that lead time for carburetor vent modifications is the longest tooling lead time requirement for a 2.0 g/test standard.

In May 1975, Ford also indicated that they would need to use EGR cooling, requiring a tooling lead time of 22 to 24 months, to meet a 6.0 g/test evaporative standard. However, Ford has complied with the 6.0 g/test standard without EGR cooling and it is not expected to be used in their 2.0 g/test systems.

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(1) "Comments in Response to the Notice of Proposed Rulemaking, published in 40 Fed. Reg. 2022 et seq., dated January 13, 1976," Ford Motor Company, February 27, 1976.

The manufacturers also agree reasonably well on the time required for the production design, development, and testing before tooling can begin. The estimates for the 3 largest manufacturers, as shown in Table I, range from 7 to 9 months.

Prior to the production design, development and testing, the hardware to be used on each vehicle-engine combination must be defined. Since many 1978 emission certification vehicles and several modified vehicles have given evaporative test results of less than 2.0 g/test, the technical feasibility of producing vehicles to meet this level has already been demonstrated[2,3]. Defining the required hardware for all vehicles will be a process of applying the current technology to attain an effective system for each vehicle-engine combination.

The amount of additional time required for defining the hardware is dependent on several factors. Perhaps the major factor is the quantity and quality of evaporative emission control work which has already been done by the manufacturers. Since a SHED evaporative standard of 6.0 g/test was implemented for the 1978 model year, all manufacturers have already defined, designed, and tooled hardware for the 6.0 g/test standard. This has developed much information which can be applied to defining hardware for a 2.0 g/test standard.

GM, Ford and Chrysler have supplied the EPA with a sizable amount of data from evaporative emission testing of various control system configurations. Each of these three manufacturers have tested systems which gave below 2 g/test (described in reference (3)). In addition, vehicles modified and tested by Exxon Research and Engineering under Contract No. 68-03-2172 (reference (2)) gave test results of less than 2 g/test, and many 1978 certification vehicle test results were under 2.0 g. So the hardware required for several vehicle-engine combinations has already been defined. Continuing effort will be required to determine which specific combination of hardware will be effective for other vehicle-engine combinations. Although it is not expected that costly modifications will be required, it will take some time to determine which modifications are necessary.

Another important consideration in lead time requirement is cost of the control system. If an inadequate period of time is allowed for defining the hardware, the control system may be more complex and cost more than necessary.

b. Because of essentially non-existent lead time estimates from the manufacturers for a 2.0 g/test standard, the above analysis was based on manufacturer lead time estimates for a 6.0 g/test standard.

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(2) 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.

(3) "Technical Feasibility of a 2 g/test SHED evaporative Emission Standard for Light Duty Vehicles and Trucks, Issue Paper by Michael W. Leiferman, U.S. EPA, Ann Arbor, Michigan, June, 1976.

If additional carburetor changes are necessary for the 2.0 g/test standard, the tooling lead time for this modification should be no greater than for the 6 g/test standard. Assuming that carburetor machining changes will require the longest tooling lead time of all equipment changes, tooling will need to begin by about June 1978 as shown in Table I.

Automotive manufacturers have estimated that production design, development and testing for a 6 g/test standard must begin 7 to 9 months before tooling can begin. Due to the increased difficulty of meeting a 2.0 g/test standard, it would be expected that, without any prior SHED test work, this phase of the program would take longer than 7 to 9 months. However, with implementation of the 6.0 g/test standard, considerable experience has been gained by the manufacturers in regards to designing systems to comply with a SHED test procedure. Considering this prior experience, it is believed that a production design and testing time of 7 to 9 months prior to hardware tooling for a 2.0 g/test standard is reasonable.

Based on lead time estimates for tooling and production design, development and testing, the date by which the manufacturers must have defined carburetor changes is determined. As shown in Table I, a new test standard for the 1980 model year would require that GM, Ford and Chrysler have defined these changes by October 1977, November 1977, and January 1978, respectively.

It is also informative to view lead time relative to the rulemaking time table. In the event that carburetor changes are needed, most manufacturers must have defined the hardware prior to expected rule promulgation (March, 1978).

C. Status of Manufacturers as of November, 1977.

On January 13, 1976 the Notice of Proposed Rule Making for both the 6.0 and 2.0 g/test standard was published. When final rule making for the 6.0 g/test standard was published (August 23, 1976), the original regulatory action was divided into two separate rule making actions. The August 23, 1976 publication stated that "final rulemaking for a longer term evaporative emission standard is presently being considered" and the 1978 standard will remain in effect for subsequent model years "until revised". These and other statements in the August 23 publication (as well as discussions between manufacturer and EPA representatives which followed) enforced the EPA's position that a standard less than 6.0 g/test was being developed and would be promulgated when some issues regarding its implementation were resolved. It was assumed that the manufacturers would make valuable use of the additional lead time, since they had stated in comments to the NPRM that more effective control equipment needed to be designed and developed in order to meet a 2.0 g/test standard.

At a EPA hearing in May, 1977 regarding California's request for waiver of 2.0 g/test standard (with a 1.0 g/test allowance for non-fuel emissions from data vehicles) in 1980, only three manufacturers (AMC, Ford and GM) presented information concerning their development efforts to achieve low evaporative levels. Considering the imminence of both California and Federal regulations more stringent than the 6.0 g/test standard, the level of effort by most manufacturers was not as high as anticipated. The level of effort and current status of some of the largest manufacturers are discussed below:

Ford - They basically supported the California request for waiver of a 2.0 g/test evaporative emission requirement in 1980. At these waiver hearings Ford presented test results from a program aimed at identifying the source of and eliminating HC emissions from carburetors. Their aggressive effort and success in developing effective evaporative control system is demonstrated by the fact that 61% of the valid certification tests on Ford's 1978 certification vehicles (conducted at EPA's Ann Arbor facility) gave results below 2.0 g. Ford is currently confident that about two-thirds of their present vehicles will meet a 2.0 g/test requirement with two modifications--(1) improved sealing and gasket materials and (2) improved canister purging. They also expect these two modifications to be adequate for the remaining one-third of their vehicles; however, this hasn't yet been determined[(4)]

GM - They favored a nationwide standard in 1981 as opposed to a California 2.0 g/test standard in 1980. They stated that a 2.0 g/test standard was not technologically feasible for the 1980 model year. Their lack of aggressiveness in developing 2.0 g/test control equipment is demonstrated by the fact that Rochester Products did not start working on the carburetor leak problem until this year (1977). Because of the slow pace in development, GM has now stated that 20 months time is required for them to obtain some of the equipment (air cleaner containing activated carbon) which is needed to meet a 2.0 g/test standard.[(5)]

Others - AMC presented a small amount of data at the California waiver hearing and stated their dependency on the carburetor manufacturers for a "leak-proof" carburetor. Little or no information has been submitted by any other manufacturers since comments to the NPRM; and consequently their status in regards to lead time for a 2.0 g/test evaporative standard is not known.

[(4)] Information obtained in a phone conversation on October 19, 1977 with Donald Buist, Executive Engineer for Certification, Ford Motor Company.

[(5)] EPA Memorandum to the File entitled, "Meeting with General Motors Concerning Lead Time Necessary for Implementation of a 2.0 g/test Evaporative Emission Standard for Light Duty Vehicles and Light Duty Trucks," November, 1977.

Conclusion

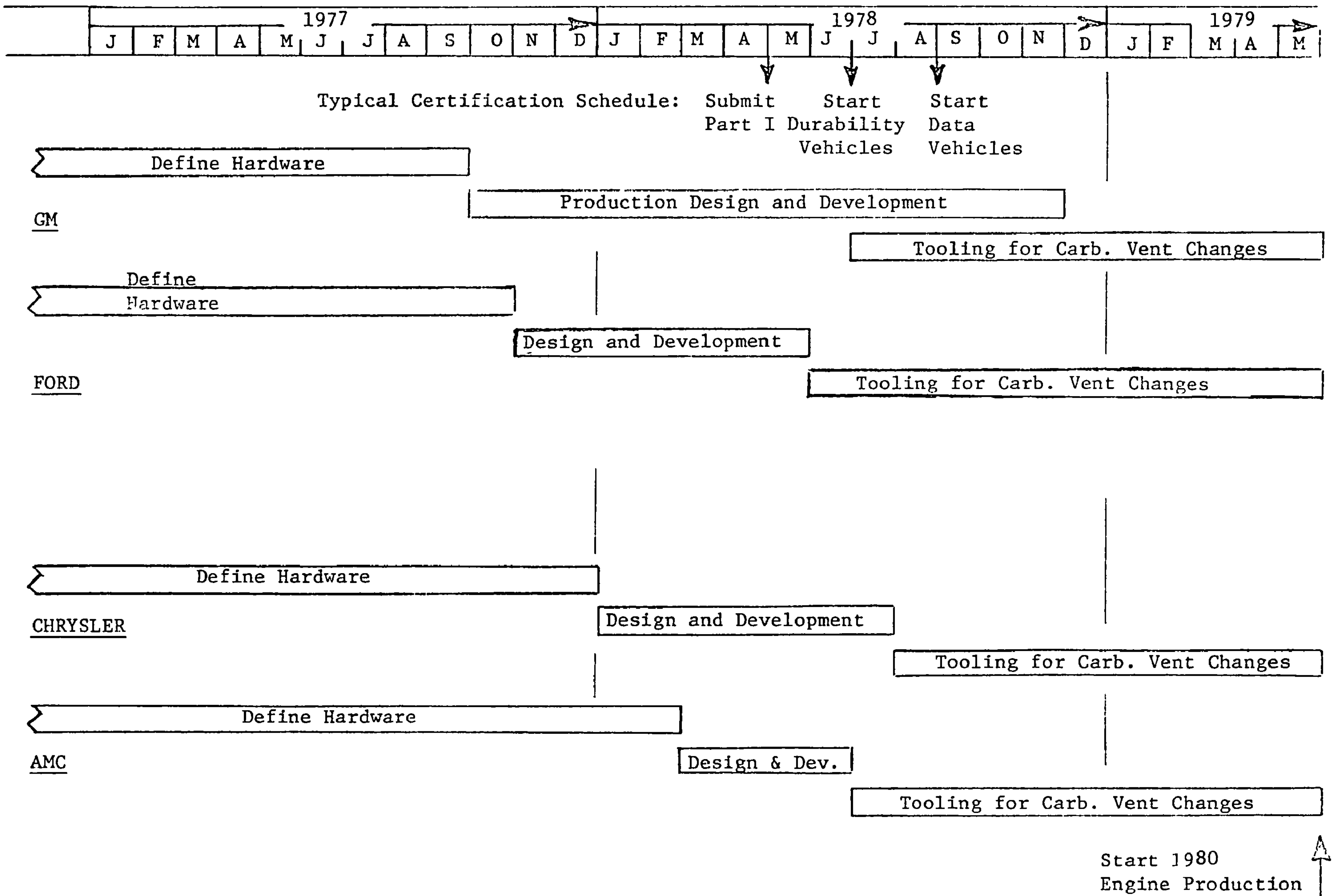
Although some manufacturers may have little trouble meeting a 2.0 g/test requirement in 1980, others have made such little constructive development effort that they would be faced with a high degree of risk if such a standard were promulgated. In retrospect, if any lesson can be learned from the development of the 2.0 g/test evaporative package, it is that delaying rule promulgation to give manufacturers requested time for development of control systems is an ineffective way of reducing emissions.

If, as one manufacturer stated, 20 months lead time is now required to obtain the necessary control equipment, a 1981 implementation date would provide the necessary time for hardware design and tooling. A 1981 implementation date may also result in the use of some control system components which would be more cost-effective and more durable than those which might be used for 1980. For example, a 1981 implementation date would hopefully allow manufacturers time to develop hot soak control measures which will not require the use of equipment which needs periodic replacement, such as engine air filters.

4. Recommendation

It is recommended that the proposed 2.0 g/test evaporative standard be promulgated for the 1981 model year.

Table I. Lead Time Considerations for a New SHED Evaporative Standard in 1980

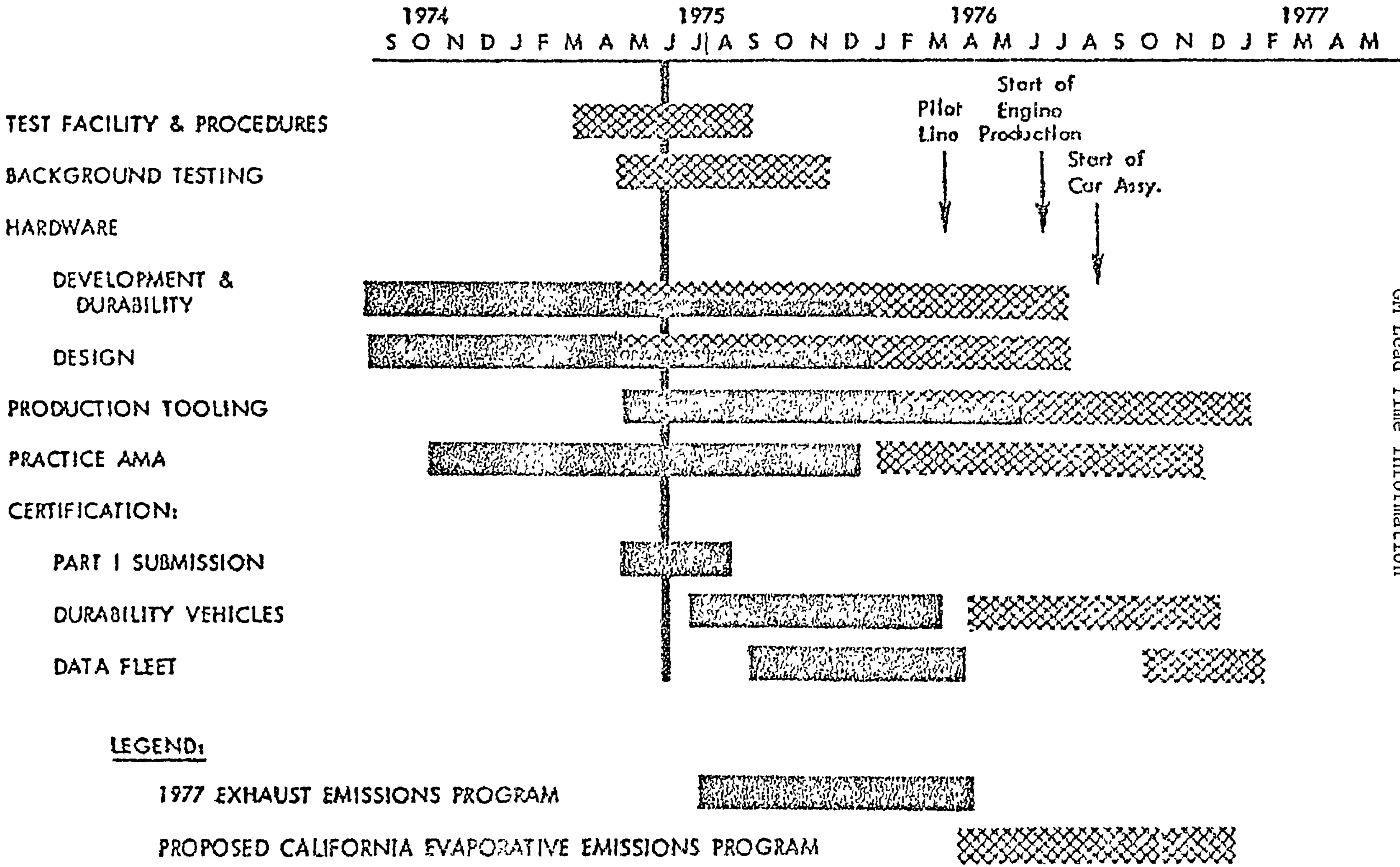


APPENDIX

Lead-time Information Submitted by
Automotive Manufacturers in Regard to the
California Waiver Request for a
6 g/test Standard in 1977

ATTACHMENT 2

1977 EMISSIONS PROGRAM



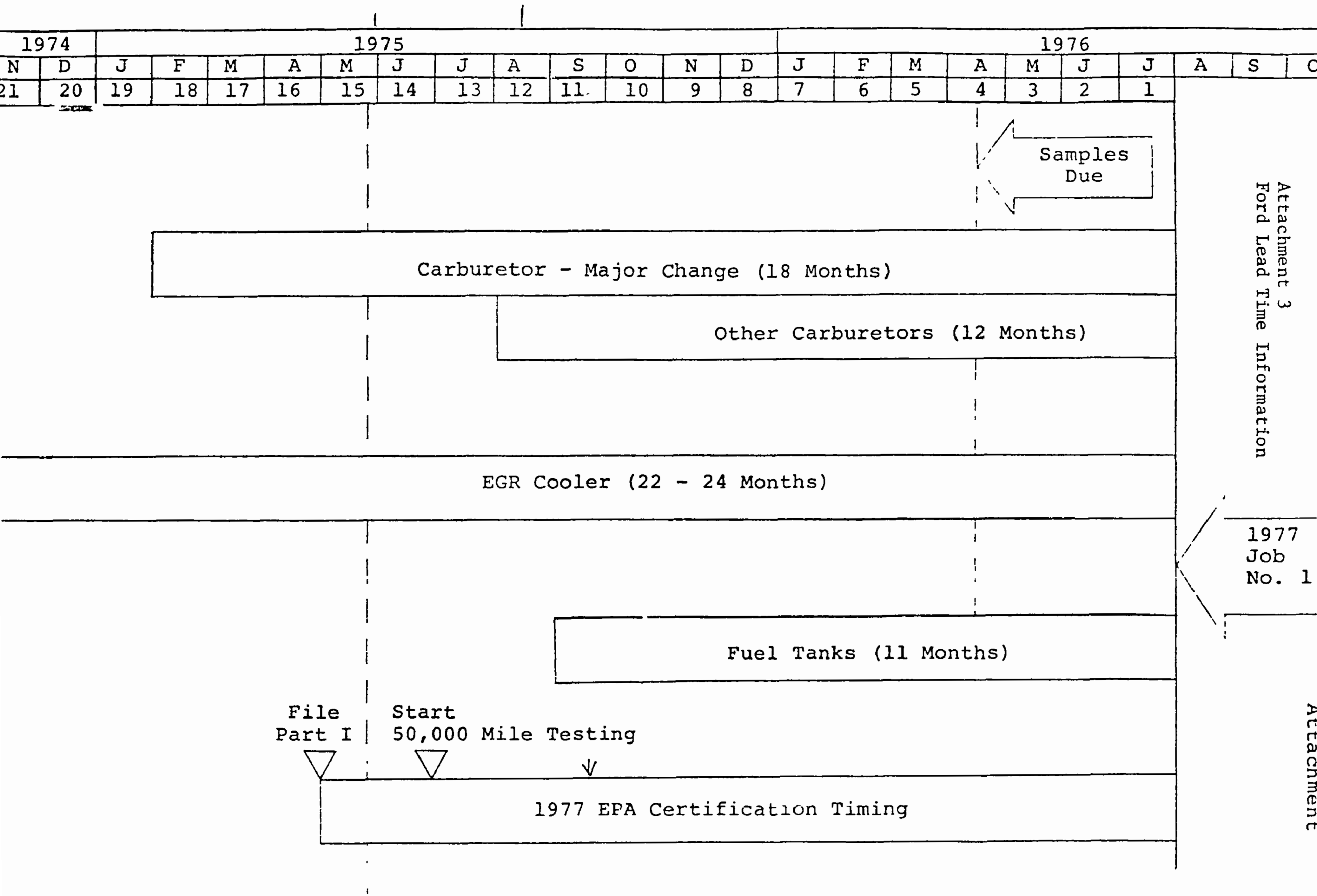
Attachment 1
GM Lead Time Information

Attachment 2
Ford Lead Time Information

The impact of the tooling lead time is summarized by passenger car engine family in the following table:

Engine	Carburetor Lead Time Series/Months	EGR Cooler 22-24 Months	Fuel Tank 11 Months
2-3L I-4	5200 / 12	Not required	x
2.8L V-6	2700 / 18	Not required	x
200 CID I-6	YFA / 12	Not required	x
250 CID I-6	YFA / 12	x	x
302 CID V-8	2700 / 18	Not required	x
351W CID V-8	2150 / 12	Not required	x
351M/400 CID V-8	2150 / 12	x	x
460 CID	4350 / 12	x	x

1977 SHED TEST
CONTROLLING COMP( )T TOOLING TIME
(EXCLUSIVE OF CONCEPT FEASI..LITY AND PRODUCTION DESIGN)



Attachment 3
Ford Lead Time Information

Attachment

Issue Paper

Cost effectiveness of a 2.0 g/test SHED Evaporative Standard for Light Duty Vehicles and Trucks

June 1976

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U.S. Environmental Protection Agency

Cost Effectiveness of a 2.0 g/test SHED Evaporative Standard for Light Duty Vehicles and Trucks

1. Statement of the Problem

What is the cost effectiveness of reducing light duty vehicle SHED evaporative emissions from a level of 6.0 g/test to 2.0 g/test?

2. Facts Bearing on the Problem

a. Exxon Research and Engineering Company conducted an evaporative test program under EPA Contract No. 68-03-2172[1]. In this study, six production vehicles which represented the four major U.S. manufacturers and two foreign manufacturers, were modifed in order to reduce evaporative emissions. Costs for the required modifications were then estimated. The resulting manufacturers' sales weighted retail price increase to achieve an evaporative level of less than 6 g/test on each vehicle was $2 per vehicle. The sales weighted retail price increase to achieve an evaporative level of less than 2.0 g/test on each vehicle was $3 per vehicle.

b. Automotive manufacturers have supplied evaporative emissions data on vehicles equipped with experimental control systems. Some of the vehicle test data submitted by GM, Ford and Chrysler were less than 2.0 g/test. The increase in vehicle retail price for these modifications was estimated based on Exxon's Contract No. 68-03-2172 cost estimates. From this information, the calculated sales weighted retail price increase (over 1976 production vehicles) to achieve the 2.0 g/test level was $7 per vehicle.

c. For the twenty production vehicles tested for evaporative emissions under Contract No. 68-03-2172, 83% of the emissions occurred during the hot-soak test and 17% during the diurnal test. For the six vehicles modified to an evaporative level of less than 2.0 g/test, 59% of the emissions occurred during the hot-soak and 41% during the diurnal.

3. Discussion

a. In the Exxon program, the vehicles which were eventually modified were also tested for evaporative emissions in their production configuration. In production form all six vehicles had evaporative emissions greater than 6.0 g/test. On most of these vehicles several different modifications were made during the test program. At some point in the program, the evaporative emissions from each vehicle decreased from a value above 6.0 g/test to a value of below 6.0 g/test. Based on the cost of these modifications, the retail increase required to achieve the 6.0 g/test level was estimated. As explained in reference (1), the estimated vehicle retail price increase for a certain modification

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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, June 1976.

is assumed to be twice the cost to the manufacturer of that modification. The modifications performed on each vehicle and the estimated price increase are listed in Table I. As shown, the estimated retail price increase of the modifications ranged from $1.10 to $5.70. The resulting manufacturers' sales weighted average is $2[2]

After final modification, each of the six vehicles in the Exxon program had an evaporative emission level of less than 2.0 g/test. The retail price increase estimate was made and these are contained in Table II. As shown the retail price increase estimates ranged from $2.00 on the Ford to $25.20 on the Mazda. The cost on the Mazda consisted mainly of the underhood ventilating fan cost. Also worth mention is the fact that the costs for the Pontiac are those associated with the Vega canister system, not the ventilating fan system which was also tested.

On a manufacturer's sales weighted basis, the retail price increase to reduce evaporative emissions from the current production level to the 2.0 g/test level is $3 per vehicle. This value was calculated similarly to the 6.0 g/test cost as previously discussed. A detailed listing of the modifications and corresponding emission levels for each vehicle are contained in Attachments A-I through A-VI of Appendix A. Attachment VII of Appendix A summarizes the initial and final emission levels for the six vehicles.

b. Attachment B-I of Appendix B lists test results and information on ten experimental vehicles which have given SHED evaporative test results of less than 2.0 g/test. These vehicles were prepared and tested by their respective manufacturers. Data on the GM and Ford vehicles were supplied in response to California and Federal proposed evaporative regulations, and the Chrysler data was contained in Chrysler's, "Progress Report on Chrysler's Efforts to Meet the 1977 and 1978 Federal Emission Standards for HC, CO and NOx" (Dec. 1975). Using this information, along with the equipment cost information in Exxon's work under Contract No. 68-03-2172, the estimated vehicle retail price increase for the modifications on the vehicles listed in Table B-I has been calculated. This information is contained in Table III. As shown the cost of the modifications on these ten vehicles range from $0.50 for the Chrysler 6-cylinder vehicle to $13.25 for the Ford vehicles.

The Ford control system listed in Table III is the one that Ford has already developed to meet a 6 g/test standard. As indicated in Table III, Ford estimates the cost of this system as $15.00. This agrees quite well with the value of $13.25 which was obtained by summing the costs of the major components of the system. GM and Chrysler did not supply cost information for the modifications listed. Using the Ford cost estimate of $15.00 for the Ford system and the cost estimate as described above for the GM and Chrysler vehicles, the average costs of the GM, Ford, and Chrysler systems listed in the Table III are $3.75, $15.00 and $2.25 respectively. A sales weighted average of these costs

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[2] Based on sales data in "Automotive News Almanac," 1975 and "Automotive News," Mar. 22, 1976.

Table I. Summary of Vehicle Modifications and Costs in Achieving a 6.0 g/test Level (EPA Contract No. 68-03-2172)

Vehicle	Modifications		Cost, $
'75 Ford	Canister replacement with PCV purge		1.00
	Seal carburetor leak		0.30
	Barrier in air cleaner		0.20
	Air cleaner sealing		0.30
	Canister bottom cap		0.20
		Total	2.00
'75 Pontiac	Bowl vent to canister		0.50
	Seal carburetor leak		0.30
	Air cleaner sealing		0.30
		Total	1.10
'75 Chrysler	Canister replacement		4.00
	Canister bottom caps		0.40
	Bowl vent to canister		0.50
	Barrier in air cleaner		0.20
	Seal carburetor leak		0.30
	Air cleaner sealing		0.30
		Total	5.70
'74 Hornet	Seal carburetor leak		0.30
	Bowl vent to canister		0.50
	Air cleaner sealing		0.30
		Total	1.10
'74 Mazda	2 bowl vents to canister		1.00
	Canister installation		6.00
		Total	7.00
'74 Volvo	Canister replacement		1.00
	Heat shield between tank and muffler		1.00
		Total	2.00

Table II. Summary of Vehicle Modifications and Costs in Achieving a 2.0 g/test Level (EPA Contract No. 68-03-2172)

Vehicle	Modifications		Cost, $
'75 Ford	Canister replacement		1.00
	Seal carburetor leak		0.30
	Barrier in air cleaner		0.20
	Air cleaner sealing		0.30
	Canister bottom cap		0.20
		Total	2.00
'75 Pontiac	Bowl vent to canister		0.50
	Seal carburetor leak		0.30
	Air cleaner sealing		.30
	Canister replacement with PCV purge		1.20
		Total	2.30
'75 Chrysler	Canister replacement		4.00
	Canister bottom caps		0.40
	Bowl vent to canister		0.50
	Barrier in air cleaner		0.20
	Seal carburetor leak		0.30
	Air cleaner sealing		0.30
		Total	5.70
'74 Hornet	Seal carburetor leak		0.30
	Bowl vent to canister		0.50
	Air cleaner sealing		0.30
	Canister replacement with PCV purge		1.00
	Canister bottom cap		0.20
	Barrier in air cleaner		0.20
		Total	2.50
'74 Mazda	2 bowl vents to canister		1.00
	Canister installation with PCV purge		7.00
	Underhood ventilating fan		17.00
	Canister bottom cap		0.20
		Total	25.20
'74 Volvo	Canister replacement		1.00
	Heat shield between tank and muffler		1.00
		Total	2.00

Table III. Estimated Increase in Vehicle Retail Price for Manufacturer Designed and Tested Systems Which Have Yielded Evaporative Losses Less Than 2.0 g/test

Vehicle No.	Vehicle Make	Modification	Cost, $
1	Oldsmobile	Dry canister (PCV purged)	0.60
		Sealed door in air cleaner snorkel	3.40(1)
		Bowl vented to canister	0.50
		Total	4.50
2	Chevelle	Vapor purge valve (PCV purged)	0.60
		Bowl vented to canister	0.50
		Internal vent closed (2-way bowl switch)	4.00(1)
		Total	5.10
3	Chrysler	2-way carburetor bowl vent switch	4.00
4	Chrysler	Bowl vented to canister	0.50
5 & 6	Ford	Bowl vent valve	3.00
		Enlarged canister	3.00
		PCV purged canister	0.60
		Auxiliary canister	3.00
		Electronic air cleaner door	3.40
		New gas cap	0.25
		Total	13.25 (15.00)(2)
7	Oldsmobile	Manually operated carb. bowl switch	3.00
8	Oldsmobile	Vacuum operated carb. bowl switch	3.00
9	Oldsmobile	Bowl vent to canister	0.50
		Door in air cleaner snorkel	3.40
		Total	3.90
10	Oldsmobile	Manually operated carb. bowl switch	3.00

(1) From manufacturers' comments on "Proposed Evaporative Emission Regulations for Light Duty Vehicles and Trucks", January 13, 1976.

(2) Ford's estimate for this system submitted to the EPA on February 27, 1976.

results in an estimated retail price increase (as calculated in Exxon's contract work) to reduce evaporative emissions from the current production level to 2.0 g/test of $7 per vehicle.

c. The cost-effectiveness of emission control strategies is commonly presented in units of dollars per ton of pollutant removed. To calculate such a cost-effectiveness for evaporative emission control, it is convenient to express the evaporative emission reduction in units of g/day and then g/mi. To calculate g/day, a relationship between the quantity of hot-soak and diurnal emission must be assumed. Based on Exxon test results under Contract No. 68-03-2172, it is assumed that vehicles at a 6 g/test level will emit 80% during the hot soak test and 20% during the diurnal; and vehicles at a level of 2 g/test will emit 60% during the hot-soak and 40% during the diurnal.

The above assumption, along with the assumption that the average vehicle undergoes 3.3 hot-soaks per day[3], results in evaporative hydrocarbon (HC) emissions of 17 g/day for a 6.0 g/test level vehicle, and 4.8 g/day for a 2.0 g/test vehicle. Assuming that the average vehicle travels 29.4 mi/day[3], the 6.0 g/test level vehicle and the 2.0 g/test vehicle emit 0.58 and 0.16 g/mi of HC evaporative emissions, respectively. The reduction in decreasing from 6.0 g/test to 2.0 g/test is 0.42 g/mi. Assuming a vehicle lifetime of 100,000 miles, this reduction in HC emission over the lifetime of the vehicle is 0.046 tons.

The contract work done by Exxon showed that the estimated sales weighted increase in vehicle retail price in going from a 6.0 g/test level to a 2.0 g/test level was $1. Estimating the associated reduction in HC emission over the life of the vehicle as 0.046 tons, the cost effectiveness is $22/ton.

The sales weighted cost estimate for the manufacturer's experimental systems which achieved 2.0 g/test was $7. This is $5 greater than the $2 cost of the Exxon modifications used to achieve a 6.0 g/test level. Assuming this $5 incremental cost, the cost effectiveness of going from 6.0 g/test to 2.0 g/test becomes $109/ton.

4. Summary

The cost effectiveness of removing HC emissions via reducing light duty vehicle and truck evaporative emissions from 6.0 g/test to 2.0 g/test has been estimated from both EPA contract study and manufacturers' supplied data. The cost effectiveness values obtained from these two sources of data are $22/ton and $109/ton, respectively. The true cost effectiveness of reducing evaporative emissions from 6.0 g/test to 2.0 g/test on a nationwide basis is expected to be between these two estimates.

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(3) "Compilation of Air Pollutant Emission Factors, Supplement 5", U.S. EPA, December 1975.

Appendix A

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	

Attachment A-I

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 (c) Bottom on each canister (d) Barrier at base of snorkel (e) Accel. pump shaft leak sealed	1.9 2.0	

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	

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

			Evaporative Emissions, g					Exhaust Emissions, g/mi[1]		
Vehicle	Engine	ECS Condition	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.

Appendix B

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.

APPENDIX to the ANALYSIS OF COMMENTS

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