ENVIRONMENTAL IMPACTS OF IMPLEMENTING A LOW PRESSURE EVAPORATIVE TEST IN THE CALIFORNIA SMOG CHECK PROGRAM

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This report reviews technical issues and describes the environmental benefits of adding a low pressure evaporative test to California's Smog Check program. In August 2000 California committed to several program improvements necessary to meet Federal Clean Air Act requirements. Specifically, California's State Implementation Plan (SIP) requires that additional emission reductions be achieved by 2010. The low pressure evaporative test will provide 14 tons per day needed to meet this obligation.

Since 2000 ARB staff has worked with the Bureau of Automotive Repair to ensure the low pressure evaporative test is a cost-effective emission reduction strategy meeting all applicable requirements. The key factors considered in the calculation of environmental benefits include the affected vehicle fleet, vehicle failure rate, compliance rate, emission reductions, costs, and errors of commission. We found this test to be a very cost-effective emission reduction strategy.

Tester Background

The low pressure evaporative test is designed to identify vehicles with evaporative emission control problems. The test evaluates whether the vehicle's evaporative control system holds pressure. Significant pressure loss is a sign of an evaporative leak causing excess reactive organic gases (ROG) or unburned gasoline to be emitted into the atmosphere. ROG is a component critical to the formation of high levels of ozone and fine particulate matter.

The low pressure evaporative tester is a stand alone device that operates independently of the smog check emissions analyzer. The tester has a built-in modem, which upon exceeding a predetermined record count, transmits records to the manufacturer's data depots. The Bureau of Automotive Repair (BAR) then receives the test results from the equipment manufacturer. Unlike testers used in other states, the California tester compensates for fuel tank fill level, fuel volatility, and liquid fuel temperature, which affect testing repeatability.

Affected Vehicle Fleet

The low pressure evaporative test is applicable to a subset of the smog check inspection fleet. The test identifies evaporative leaks in 1976 to 1995 model year vehicles that are not equipped with an on-board diagnostics system (OBD II). However, due to physical constraints, technicians are unable to perform the test on some of the 1976 to 1995 model year vehicles.

Understanding what portion of the vehicle fleet is actually testable is critical for determining both the emission reductions and the cost-effectiveness of the low pressure evaporative test. The testable fleet is model years 1976 to 1995 vehicles that do not have some physical constraint making testing not practicable.

Due to statistics from other states' low pressure evaporative test programs, ARB had concerns that a large percentage of the non-OBD II fleet could not be physically tested. Arizona, Delaware, and Kentucky have implemented a low pressure evaporative test as part of their centralized programs, with reported testability rates of 60 percent, 50 percent, and 18 percent, respectively, of the non-OBD II fleet.

In order to perform the test, the smog check technician must clamp a hose near the evaporative canister. Ranges in testability could be due to inaccessible hoses and differing concerns of hose damage due to the clamp. In response, BAR developed a pinch-point database to aid technicians in locating the appropriate location to seal the hose. BAR also studied various clamps and approved specific clamps to be used with the tester to improve testability. Using the latest information and a production-ready tester, BAR conducted roadside tests in early 2005 on over 1500 vehicles to assess the testability variable. During the roadside tests, BAR determined that 91.8 percent of the California non-OBD II vehicle fleet was testable under optimum conditions.

Failure Rate

The failure rate is a key statistic used to determine both the applicable emission reductions and cost-effectiveness of the low pressure evaporative test. From roadside testing conducted by BAR in 2005, an initial failure rate of 11.1 percent was observed. Even though roadside vehicles are pulled over randomly, the vehicle fleet tested at roadside did not exactly represent the California vehicle population. To get an accurate failure rate for the California fleet, BAR weighted the failure rate results from the roadside tests with the California fleet population for 2005 to get a fleet failure rate of 10.6 percent. In calendar year 2010, the non-OBD II vehicle fleet will be five years older and more deteriorated. In order to estimate the failure rate for calendar year 2010, BAR plotted the failure rate by model year trend in 2005 and then shifted the trend five years weighted by the 2010 vehicle population. Using this method, BAR estimated that the low pressure evaporative test failure rate would be 18.7 percent in 2010.

Compliance Rate

Another factor used to estimate emissions benefits is the portion of potential failures that are actually detected and given lasting repairs. This has been termed the compliance rate. The compliance rate is critical to estimating realistic emission benefits since not all failing vehicles will be identified and not all repairs will be durable enough to last two years. Recent roadside data showed that 59.6 percent of vehicles that had failed a smog check inspection and were subsequently repaired passed at roadside within six months. ARB assumed the same success rate for evaporative testing during the first inspection cycle, i.e., 59.6 percent of failing vehicles will be correctly identified and repaired. In other words, 40.4 percent of failing vehicles will not be correctly identified and repaired.

If implemented before 2007, two smog check inspection cycles will occur before 2010 for all vehicles. During the first inspection cycle 40.4 percent of the vehicles will not be correctly identified and repaired. ARB applied the success rate to the second inspection cycle for vehicles not correctly identified in the first inspection cycle (59.6 percent X 40.4 percent) and determined that 24.1 percent of these vehicles will be identified and repaired during the second inspection cycle. Since these vehicles were not correctly identified during the first inspection cycle, ARB assumed they were more difficult to identify and repair. To be conservative, ARB discounted the success of the second inspection cycle by a factor of two for a 12 percent identification and repair rate.

Thus, an overall compliance rate in 2010 would be the total for the two inspection cycles, 71.6 percent.

Emission Reductions

There are three types of evaporative emissions: running losses, hot soak, and diurnal losses. Running losses are evaporative emissions that emanate while the vehicle is being operated. Hot soak emission losses are emitted from a vehicle immediately after the engine is turned off. Diurnal emissions occur as a result of the vehicle’s fuel heating and volatilizing as the ambient temperature rises and declines during the day.

In support of the low pressure evaporative test, ARB performed evaporative emission testing for BAR on ten vehicles in 2002 and three vehicles in 2005 that failed a roadside low pressure evaporative test. ARB conducted pre- and post-repair diurnal loss evaporative emissions tests to evaluate the benefits of repair. In 2005, ARB also conducted pre- and post-repair hot soak loss evaporative emission tests.

In a 2001 report prepared for BAR, Eastern Research Group (ERG) evaluated the emission benefits of various evaporative emission tests including a low pressure evaporative test. ERG evaluated pre- and post-repair running loss, hot soak loss, and diurnal emissions on eleven vehicles that failed the low pressure evaporative test.

ARB used the results from these three test programs to estimate the percent emission reduction due to repairs for each type of evaporative emissions loss. To calculate the emission benefit for 2010, ARB assumed that the test was applicable to 1976-1995 model year light duty vehicles, 91.8 percent of those vehicles are testable, 18.7 percent of those vehicles will fail the test, and 71.6 percent will comply with the test. ARB determined that in 2010, 711,197 vehicles would fail and be correctly repaired due to a low pressure evaporative test over two inspection cycles. Using the EMFAC2002 emissions model, ARB estimated the per vehicle emissions for each of the three types of evaporative emission losses in calendar year 2010. Using this data, ARB applied the percent reduction per type of loss and estimated the low pressure evaporative emission benefits. The results from this analysis (See Table 1) show a 14.0 tons per day (tpd) reduction in ROG in 2010.

Table 1

Evaporative Test Benefits in Calendar Year 2010			
	Baseline Emissions (grams/day/vehicle)	Percent Reduction from Evap. Test	Emissions Benefit (tons per day)
Hot Soak	4.1	80.0%	2.5
Diurnal Loss	2.7	76.6%	1.6
Running Loss	13.0	97.4%	9.9
Total Emission Benefits from Evaporative Testing			14.0

ARB assumes that the vehicles from the three test programs reasonably represent the failing fleet.

Costs

The low pressure evaporative tester costs between $2,500 and $3,000 to purchase and $100 annually to maintain. Most stations will amortize this cost over five years, adding $1.50 per test to the smog check inspection cost. BAR estimated that the overall smog check inspection time will increase by five minutes with the addition of the low pressure evaporative test. At current prevailing labor rates, the extra time will add about $6 per test to the smog check inspection cost. Therefore, BAR and ARB estimated that incorporating the low pressure evaporative test will increase the smog check inspection cost by $7.50.

In 2002 and 2005, ARB and BAR jointly evaluated emission benefits and repairs from a low pressure evaporative test. For vehicles that failed the low pressure evaporative test, the 2002 and 2005 evaporative testing programs indicated that the repair costs averaged approximately $161 per vehicle. The majority of the repairs included replacing damaged or reconnecting disconnected vapor lines, repairing the fuel tank, replacing seals associated with the fuel level sending unit, and correcting problems associated with the fuel filler neck. These types of repairs are durable and tend to last at least five years. According to the repair data, most of the repair cost is labor. The parts costs are relatively minor.

Since excess evaporative emissions are basically unburned gasoline, repairing the vehicle will reduce fuel consumption and save consumers money. With

California gas prices averaging over $2.77 per gallon, consumers could save over $4,500,000 in fuel costs annually by repairing evaporative leaks.

Cost-Effectiveness

Cost-effectiveness is calculated by dividing the total costs of the low pressure test by the total emission reductions. From the information above, ARB assumed the following to calculate the cost-effectiveness of implementing the low pressure evaporative test in 2010:

Number of vehicles per test cycle:	5,783,020
Percentage of vehicles testable:	91.8%
Compliance rate	71.6%
Failure rate:	18.7%
Average repair costs:	$161
Increase in test cost:	$7.50
Emission Reductions:	14.0 tpd
Life of repairs:	5 years
Discount rate:	3%

As stated earlier, the majority of evaporative leak repairs are replacing or reconnecting parts. Replacement parts tend to be durable for at least five years. To accurately reflect the life of the repair in the cost-effectiveness calculation, ARB used the annualized cost of repairs. The annualized cost of repairs is equal to the capital recovery factor[1] (CRF) times the capital cost.

$$CRF = \left[\frac{1}{1+i} + \frac{1}{(1+i)^2} + \dots + \frac{1}{(1+i)^n} \right]^{-1} = \frac{i(1+i)^n}{(1+i)^n - 1},$$

CRF=.03*(1+.03)^5/(1+.03)^5-1 = .2183
Annualized cost = .2183* $161=$35.15

Consumer cost per test cycle
Consumer cost= 5,783,020 vehicles*$7.5 + .918*.716*5,783,020*.187*$35.15
Consumer cost= $68,357,534

Cost-effectiveness= $68,357,534/(14.0 tpd*2*365)
Cost-effectiveness=$6688/ton

This is very favorable cost-effectiveness compared to other SIP strategies. For example, the cost-effectiveness requirement for expenditure of Carl Moyer Incentive Program funds is $14,300. This cost-effectiveness of a low pressure evaporative test is well below that cap.

[1] Capital recovery factory is used to annualize funding dollars according to a project's life.

Error of Commission

Health and Safety Code Section 44013(c) specifies that emission standards and test procedures prescribed by BAR shall ensure that not more than five percent of the vehicles or engines, which would otherwise meet the requirements of this part, will fail the inspection and maintenance test for that class of vehicle or engine. Such failures are termed errors of commission.

ARB recently conducted an error of commission analysis of the low pressure evaporative test. Details of this analysis were reported to BAR in an October 4, 2005 memorandum. ARB recruited vehicles that had recently failed a roadside screening test for evaporative emissions. Each vehicle was tested at ARB's facility using the low pressure evaporative test to confirm an evaporative system leak. If a vehicle failed the test, ARB attempted to diagnose and repair the failure. Of the 31 vehicles tested, the evaporative test equipment identified 24 as having an evaporative failure. ARB staff successfully repaired each vehicle, with one exception. A 1977 Mercury Marquis was not repaired because a replacement fuel filler neck, the source of the evaporative leak, was not readily available. ARB staff did not take further steps to pursue repairs, such as contacting BAR's parts locator service, and instead released the vehicle.

Counting the 23 repaired vehicles, ARB tested and found to pass a total of 30 vehicles without an error of commission. If the error of commission rate was five percent, the probability of 30 consecutive passing results without an error is (1-0.05) raised to the power of 30, or 0.215. ARB believes the data demonstrate that the probability of the error of commission rate being less than five percent is nearly 80 percent.

In summary, ARB performed the proposed evaporative emission test on 31 vehicles that were identified during roadside testing as having possible excess evaporative emissions. Seven vehicles passed the initial evaporative test. Twenty-four of the vehicles failed the proposed evaporative emission test. The cause of the evaporative test was identified for each of the 24 vehicles. Each vehicle was successfully repaired with the one exception discussed previously, and passed a retest. No errors of commission occurred.

Conclusion

ARB concludes that the low pressure evaporative test functions properly, and is a cost-effective emission reduction strategy. The low pressure evaporative test is feasible, is needed to meet outstanding federal commitments to reduce emissions, and will help California meet health-based air quality standards. In addition, low pressure test implementation will enable federal approval of the enhanced Smog Check inspection program. Therefore, ARB recommends that BAR begin the regulatory process to implement the low pressure evaporative test immediately.