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Evaporative Emissions from the Fourteen Car DOE Gasoline/Methanol Blend Fleet

(Report from Work Assignment 7, Contract 68-03-3192 with Southwest Research Institute)

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I. INTRODUCTION

The purpose of this work was to investigate the effect on evaporative emissions of mileage accumulation with a gasoline/methanol/cosolvent splash blend versus mileage accumulation with the base gasoline. This test program was carried out under Work Assignment 7 of EPA Contract 68-03-3192 with Southwest Research Institute (SwRI) in conjunction with a one year demonstration program at SwRI sponsored by the Department of Energy . The same vehicles (fourteen 1984 Ford Escorts) were included in the previously completed Work Assignment 4, which involved evaporative emission testing with the gasoline-alcohol splash blend, the control gasoline, and a gasoline-alcohol blend matched for FEVI* to the control gasoline. Those tests were run after about 10,000 miles had been accumulated on each vehicle, and the final tests reported here were run after approximately 4,000 more miles were put on each vehicle. A copy of the Final Data Report for Assignment 4 is included as Appendix A for reference.

Work Assignment 7 involved evaporative emission testing of all fourteen vehicles with their original charcoal canisters, and retesting after the canisters had been switched between the control and blend vehicles (i.e., blend vehicles tested with the control canisters and control vehicles tested with the blend canisters). This was done to separate canister differences from vehicle differences. Canisters from two control and two blend vehicles were also weighed before and after each segment of the SHED test to help in understanding the load-purge cycle. The control fuel at the time of evaporative emission testing was a winter grade (11.5 psi RVP) unleaded fuel, but two vehicles from each group were also tested with the summer grade control fuel (9.1 psi RVP) with and without switched canisters. This testing provided a comparison back to the original evaporative emissions data from Work Assignment 4.

II. SUMMARY

Evaporative emission tests were conducted on a 14-vehicle fleet undergoing driveability testing for DOE at SwRI. Seven vehicles (200 series) accumulated mileage on an unleaded control fuel, and seven vehicles (100 series) accumulated mileage on a gasoline-alcohol blend containing four percent methanol, two percent ethanol, and two percent t-butyl alcohol (TBA). The results of experiments conducted with these vehicles are summarized below:

* FEVI: Front End Volatility Index = RVP + 0.13 (% evap @ 158°F)

A. SHED evaporative emissions from the blend vehicles at standard FTP temperatures were 32 g/test compared to 9 g/test for the control vehicles when tested with the winter grade control fuel (11.5 psi RVP, EM-620-F). Due to the use of this higher volatility fuel, these results can not be compared directly to SHED tests using 9.0 psi RVP Indolene.

B. SHED evaporative emission tests conducted on four vehicles (two of the 100 series and two of the 200 series) with the summer grade unleaded control fuel (EM-601-F) produced evaporative emissions of 3-5 g/test. Blend and control vehicles produced essentially equivalent SHED emissions with the summer grade unleaded fuel (EM-601-F).

C. When canisters were randomly switched between blend and control vehicles (i.e. blend vehicles with control canisters and control vehicles with blend canisters), the SHED evaporative emissions were essentially equivalent at 30-31 g/test with EM-620-F. Several vehicles in each group had unusually high hot soak losses which tended to overshadow any changes due to canister switching.

D. The diurnal contribution to the total SHED emissions ranged from 52 to 72 percent for both vehicle groups with EM-601-F. With the winter grade control fuel EM-620-F, the diurnal contribution ranged from 8 to 36 percent.

E. Canister weight gain appeared to be more vehicle-related than a function of previous fueling history. Canisters which gained the most weight during the hot soak also had the most breakthrough. No differences in blend or control canisters could be observed from canister weight gain or SHED evaporative emissions during the canister weighing test series.

F. In general, 36 to 42 grams of hydrocarbons/alcohols were purged from the canister during FTP operation, which was 4.3 - 5.5% of the purged weight of the canister. Canister weights at the end of the hot soak were within 11 grams (i.e., two percent) of the weight at the start of the diurnal.

II. DESCRIPTION OF VEHICLES AND FUELS

A. Vehicles

The fourteen vehicles tested in this Work Assignment were obtained immediately upon completion of a DOE fleet demonstration program which was under contract to SwRI and administered by the Fuels and Lubricants Technology Division. The fleet consisted exclusively of 1984 Ford Escorts, seven accumulating mileage on the control fuel (unleaded Amoco) and seven accumulating mileage on the blend fuel. Table 1 provides a list of the vehicles tested during this Work Assignment and the nominal odometer readings at the time the vehicles were delivered for testing.

TABLE 1. DOE TEST VEHICLES

Vehicle No.	Mileage Accumulation Fuel	Nominal Odometer Reading	License No.	Miles[a] Winter	Miles[a] Summer
101	Blend	15,100	261 EGK	3,100	12,000
102	Blend	24,200	264 EGK	4,840	19,360
103	Blend	21,000	260 EGK	4,200	16,800
104	Blend	20,600	266 EGK	4,120	16,480
105	Blend	18,100	265 EGK	3,620	14,480
106	Blend	17,000	273 EGK	3,400	13,600
107	Blend	15,000	259 EGK	3,000	12,000
201	Control	17,700	263 EGK	3,540	14,160
202	Control	24,400	267 EGK	4,880	19,520
203	Control	21,000	272 EGK	4,200	16,800
204	Control	28,700	271 EGK	5,740	22,960
205	Control	29,900	268 EGK	5,980	23,920
206	Control	18,200	262 EGK	3,640	14,560
207	Control	16,200	258 EGK	3,240	12,960

[a] Of the mileage accumulation on the winter grade version of the blend and control fuels, it is estimated that the majority of the mileage accumulation was obtained during the winter of 1983-84 (December 1983-February 1984). Only two or three tankfuls were used at the end of the mileage accumulation in December 1984.

B. Fuels

Mileage accumulation was accomplished using two fuels, a control fuel and a blend fuel. The control fuel was an unleaded Amoco fuel. The blend was prepared by adding methanol (4% volume), ethanol (2% volume) and TBA (2% volume). The nature of the DOE demonstration program did not provide strict control over the RVP (or FEVI) of the test fuels, and the fuels varied with the seasons. That is, summer grade unleaded Amoco was used during the majority of the mileage accumulation, but winter grade was used during December 1983, January 1984, February 1984, and December 1984. Table 1 also summarizes the mileage estimated to be accumulated on winter and summer grades of gasoline. The pertinent fuel inspection data are summarized in Table 2.

Based on obvious differences between the original control fuel (EM-601-F) and the control fuel in use at the end of the DOE mileage accumulation, several vehicles were tested with the limited amount of EM-601-F remaining to provide some comparison back to the original data from Work Assignment 4. The front end volatility index (FEVI) of the summer grade fuel (EM-601-F) was 12.7, compared to 15.7 for the winter grade (EM-620-F).

TABLE 2. FUEL INSPECTION DATA

Specification	ASTM	Fuel Code EM-601-F[a]	EM-620-F[b]
API Gravity 60 F	D-287	59.5	60.0
Distillation, F	D-86		
IBP		87	81
10%		119	109
50%		207	198
90%		341	331
EP		409	383
Recovery, %		98.0	98.0
Residue, %		1.0	1.0
Loss, %		1.0	1.0
% Evaporated 158 F		28.0	32.0
RVP, psig	D-323	9.1[d]	11.5
FEVI[c]		12.7	15.7

[a] EM-601-F was a summer grade unleaded Amoco gasoline used in the original emission testing conducted under Work Assignment 4 of Contract 68-03-3192.

[b] EM-620-F was a winter grade unleaded Amoco gasoline that was being used when the final testing of the DOE vehicles was initiated.

[c] Front end volatility index, FEVI = RVP + 0.13 (% Evap 158°F)

[d] A different test program which used this fuel measured the RVP to be 9.8 psi.

III. Test Procedure

Employees used the cars in everyday driving, but used only the mileage accumulation fuels. Following the completion of mileage accumulation, the fuel tanks of the seven vehicles operating on the blend fuel were run to near empty, and a tankful of the control fuel (EM-620-F) was then run through each blend vehicle over approximately a week's time using the same normal driving procedure as was used throughout the program for mileage accumulation. This was done to minimize any short term effects of the blend fuel so the testing would show mainly any long term effects of high volatility blend use.

After all mileage accumulation and the tank of base gasoline in the blend vehicles was used, there was a variable length of time ranging from about one to five days before the evaporative emission tests were run. All evaporative emissions tests were conducted according to the Federal SHED test procedure, except for the use of test fuels other than Indolene. This means that following a fuel tank drain and fill a single LA-4 preconditioning cycle was run on the dynamometer and then within 12-36 hours the tank was drained and filled to 40% of capacity and the diurnal heat build test was run. This was followed by cold and hot start LA-4 cycles on the dynamometer and then the hot soak part of the SHED test was run.

IV. RESULTS

A. Original Vehicles with Original Canisters

First, all fourteen vehicles were tested with their original canisters using EM-620-F. These results are presented in Table 3, and illustrate that the blend vehicles had an average SHED emission rate of about 32 g/test compared to 9 g/test for the control vehicles. Although the test plan had an adequate number of vehicles, no replicate tests were conducted to investigate individual vehicle variability. Since no repeats were run during this set of experiments, and there is a wide vehicle-to-vehicle and test-to-test variability as shown by this and data from the later set of experiments, the conclusions are not as firm as they otherwise might be.

The average diurnal evaporative emissions of the blend vehicles contributed about one-third (10 grams) to the overall SHED emissions compared to the two-thirds (22 grams) from the hot soak segment of the SHED test. The average diurnal contribution to the evaporative emissions of the control vehicles was 0.8 gram, whereas the hot soak produced an average of 8 grams. The difference in diurnal emissions between the blend and control vehicles was statistically significant at a

99.5% confidence level, but the difference in hot soak losses was not significant at a confidence level of 95%, due to the wide vehicle-to-vehicle scatter. The difference in total SHED emissions was significant at a 99% level.*

Initial results from these tests indicated that several vehicles (both control and blend) had noticeably higher hot soak losses than several apparently similar vehicles. Some researchers feel that the hot soak losses are more related to carburetor losses rather than canister hydrocarbon losses. Blend vehicles which had higher-than-normal hot soak losses were 102, 104, 105 and 107. Control vehicles which had higher-than-normal hot soak losses were 202, 203 and 205. The significance of these high hot soak losses is discussed in the next section with the discussion of the effect of canister switching.

B. Canisters Switched Between Control and Blend Vehicles

Canisters were switched randomly between control and blend vehicles to investigate the effect on evaporative emissions. Test results are summarized in Table 3. For the blend vehicles equipped with the control canisters, the composite average SHED evaporative emission rate was about 31 g/test with the 11.5 psi RVP fuel. The diurnal segment averaged about 4 grams compared to 27 grams produced during the hot soak. Blend vehicles 102, 103, 104 and 107 produced noticeably higher hot soak emissions than the remaining vehicles.

When the control vehicles were tested with the blend canisters with the same 11.5 psi RVP fuel, the SHED evaporative emissions went from 9 g/test in the stock configuration to 30 g/test. Control vehicles 202, 203, and 205 produced higher hot soak emissions than the remaining vehicles in that group. The diurnal emissions were about 11 g/test while the hot soak emissions were almost 20 g/test. To check for canister differences as separate from vehicle differences, we can combine these data from the switched canisters with the above data from the original canister/vehicle tests. The fourteen tests with the 100 series canisters can be compared to the fourteen tests with the 200 series canisters. This comparison shows the diurnal emissions from the blend canisters (100 series average 10.4 grams) to be greater than the gasoline

* The statistical test used was the T test for independent groups of data.

canisters (200 series, average 2.3 grams) at a 99.5% confidence level. Due to the wide scatter in hot soak data, there is no significant difference in hot soak or total emissions at a 95% confidence level. However, if the higher hot soak tests are omitted from the data, the blend canisters average 6.5 grams per hot soak compared to 3.3 grams for the gasoline canisters, and the difference is significant at a 99% level. In this case the total SHED emissions average 15.6 grams for the blend canisters versus 5.6 grams for the gasoline canisters, and the difference is significant at a 99.5% level.

It is interesting to note that in tests with the canisters from the blend vehicles the hot soak emissions were about twice the diurnal emissions. For those tests with control canisters, the hot soak was 7-11 times greater than the diurnal emission rate. Table 4 summarizes the diurnal contribution to the overall SHED emissions. In general, the diurnal segment of the SHED accounted for 50-75 percent of the composite SHED emission rate when the blend and control vehicles were tested with EM-601-F. When these same vehicles were tested with the winter grade gasoline, the diurnal segment accounted for an average of 8 to 12 percent of the SHED emissions for the control canisters and 31 to 36 percent of the SHED emissions for the blend canisters.

Based on the data presented in Table 3, it appears that the higher hot soak losses attributed to vehicles 102, 104, 105 and 107 were also observed on three of these vehicles when the canisters were switched and these vehicles were tested with the control canisters (vehicles 102, 104 and 107). A similar trend was observed for the control vehicles where 202, 203 and 205 produced noticeably higher hot soak emissions with both the blend and control canisters. Since the hot soak emissions accounted for the majority of the SHED emissions when using EM-620-F and since it appears that the vehicle may influence hot soak emissions more than the canister, it is very difficult to determine the effect of canister switching.

Although these data indicate some increase in evaporative emissions from the blend canisters (100 series) relative to the gasoline canisters (200 series), when tested with the 11.5 psi RVP gasoline, this can not simply be attributed to the presence of alcohol in the mileage accumulation fuel. The other major difference between the mileage accumulation fuels was their volatility, since the blend fuel was a splash blend with no attempt at volatility matching. Therefore it is uncertain from these data alone whether mileage accumulation on an alcohol blend fuel with a matched volatility to a base gasoline would show any difference in evaporative emissions.

TABLE 3

SUMMARY OF SHED EVAPORATIVE EMISSIONS RESULTS
(11.5 psi RVP TEST FUEL)

Vehicle[a]	Fuel	Canister[b]	SHED Evaporative Emissions, g Diurnal	Hot soak	Total
101	EM-620-F	101	6.28	7.13	13.41
102	EM-620-F	102	4.92	37.44[c]	42.36
103	EM-620-F	103	14.50	7.22	21.72
104	EM-620-F	104	10.22	57.82[c]	68.04
105	EM-620-F	105	16.13	12.25[c]	28.38
106	EM-620-F	106	3.77	5.38	9.15
107	EM-620-F	107	13.20	24.68[c]	37.88
		Avg.	9.86	21.70	31.56
		S.D.	4.94	19.74	20.11
201	EM-620-F	201	0.50	2.67	3.17
202	EM-620-F	202	0.32	10.98[c]	11.30
203	EM-620-F	203	0.44	12.35[c]	12.79
204	EM-620-F	204	0.33	2.63	2.96
205	EM-620-F	205	2.07	20.02[c]	22.03
206	EM-620-F	206	0.37	2.20	2.57
207	EM-620-F	207	1.31	7.90	9.21
		Avg.	0.76	8.39	9.15
		S.D.	0.67	6.61	7.08
101	EM-620-F	202	1.69	1.25	2.94
102	EM-620-F	201	3.85	58.44[c]	62.29
103	EM-620-F	207	6.80	52.56[c]	59.36
104	EM-620-F	204	2.04	47.84[c]	49.90
105	EM-620-F	206	2.17	3.77	5.94
106	EM-620-F	205	10.26	2.40	12.66
107	EM-620-F	203	0.34	23.97[c]	24.31
		Avg.	3.88	27.18	31.06
		S.D.	3.48	25.47	25.62
201	EM-620-F	102	10.20	9.37	19.57
202	EM-620-F	101	17.23	43.20[c]	60.43
203	EM-620-F	107	4.78	39.90[c]	44.68
204	EM-620-F	104	11.37	5.03	16.40
205	EM-620-F	106	15.26	27.53[c]	42.79
206	EM-620-F	105	6.85	3.40	10.25
207	EM-620-F	103	10.38	8.27	18.65
		Avg.	10.87	19.53	30.40
		S.D.	4.36	17.03	18.78

Table 3 (continued)

SUMMARY OF SHED EVAPORATIVE EMISSIONS RESULTS
(9.1 psi RVP TEST FUEL)

101	EM-601-F	202	1.68	1.09	2.77
102	EM-601-F	201	2.24	4.32	6.57
		Avg.	1.96	2.71	4.67
		S.D.	0.40	2.28	2.68
201	EM-601-F	102	0.43	1.00	1.43
202	EM-601-F	101	4.45	1.34	5.79
		Avg.	2.44	1.17	3.61
		S.D.	2.84	0.24	3.08
101	EM-601-F	101	5.32	0.98	6.30
102	EM-601-F	102	0.87	1.42	2.29
		Avg.	3.10	1.20	4.30
		S.D.	3.15	0.31	2.84
201	EM-601-F	201	3.42	1.06	4.48
202	EM-601-F	202	0.71	1.15	1.86
		Avg.	2.07	1.10	3.17
		S.D.	1.92	0.06	1.85

a) 100 Series Vehicles accumulated mileage on alcohol blend fuel containing 4% methanol, 2% ethanol and 2% tertiary butyl alcohol added to the baseline commercial unleaded Amoco gasoline. 200 Series Vehicles accumulated mileage on commercial unleaded Amoco gasoline.

b) The "canister" column indicates that tests on the 11.5 RVP fuel were first run with the vehicle's original canisters and then canisters were switched between the two sets of vehicles. Then testing was done with the 9.1 RVP fuel, first with the canisters switched and then with them back on their original vehicles.

c) Higher hot soak test results which may be related more to carburetor factors than canister factors.

C. Comparison of Vehicles to Original Tests

Several SHED tests were conducted with vehicles operating on EM-601-F to provide a comparison back to the original baseline. Only two vehicles of each group were included in this study. These vehicles were tested with their original canisters and with the canisters switched. These results are presented in Table 5, and are summarized and compared to the original tests conducted in Work Assignment 4. The difference between blend and control SHED evaporative emissions was not as apparent as it was during the original tests. Switching canisters did not have any effect on SHED emissions. It should be noted that only two vehicles, rather than the original seven, were used in these tests. The intent of these tests was to establish that the vehicles had not shifted significantly since the original tests in Work Assignment 4. The blend vehicles were down slightly and control vehicles were up somewhat, but in neither case was a major shift observed.

D. Canister Weighing

Two blend vehicles (101 and 102) and two control vehicles (201 and 202) were selected for additional experiments that included canister weighing during different segments of the SHED test. The purpose of these tests was to investigate the relationship between the hydrocarbons adsorbed on the charcoal and the hydrocarbons measured in the SHED. The hydrocarbons adsorbed onto the carbon were determined by canister weighing. These plus the hydrocarbons measured in the SHED test (i.e. the evaporative emissions) would be the total vapor generated. These results are presented in Table 6 for vehicles 101, 102, 201 and 202 with their original canisters. In reviewing these data, it is important to recall that two of these vehicles (202 and 102) were identified as possibly having higher soak losses due to carburetor losses rather than canister breakthrough losses. The possibility is also apparent with these two vehicles during these tests. For example, vehicle 101 produced 2 g/hot soak while vehicle 102 had about 20 g/hot soak. A similar trend was observed with vehicle 201, which produced 7 g/hot soak as compared to 18 g/hot soak for vehicle 202. Two of the three hot soak tests for vehicle 201 were 1 g/hot soak but the third test had higher (about 17 grams) hot soak losses.

Canister weight gain appeared to be more related to the specific vehicles than to the fuel used for mileage accumulation. For example, vehicles 101 and 201 had essentially equivalent canister weight gain (36 to 38 grams), although one was a blend vehicle and one was a control vehicle. Vehicles 102 and 202 were identified as vehicles with high hot soak losses. This was also observed in these experiments where canister weight gain for these two vehicles was 45 to 50 grams, with the majority of the weight gain being observed in the hot soak segment of the test.

Table 7 summarizes the actual canister weights that were observed during these experiments. The canister weights before diurnal testing were 800 ± 15 grams for canisters from both blend and control vehicles. The diurnal canister weight gain was 16 ± 6 grams with control and blend vehicles being essentially equivalent. After the vehicles had completed the FTP cycle, canisters were re-weighed and FTP losses during the canister purge were determined. These data are also presented in Table 7 and illustrate that the canisters generally lost 33 to 42 grams during the FTP purge. No difference between canisters from blend and control was observed for losses during the FTP purge. The after-hot soak canister weights were generally within 11 grams of the before-diurnal canister weight.

V. QUALITY ASSURANCE

The areas requiring quality assurance on this work assignment are SHED calibration and retention check, HC FID calibration, and balance for canister weighing. SHED calibrations, SHED retention checks and HC FID calibrations were performed using procedures and equipment specified in the Federal Register. Records of these calibrations are available to confirm that the SHED and FID-related calibrations were valid during the period when emission testing was conducted.

The balance used for weighing canisters was calibrated prior to each individual test using a 2 lb and a 1 lb weight. These data were included on the canister-weighing data sheet. The balance accuracy for reference weights was 0.04 percent or better for both the 1 lb and 2 lb weights, for all tests requiring canister weighing (Table 8).

No problems were encountered with operation or calibration for the SHED, FID, or balance, and all data should be considered valid from a strictly analytical standpoint. However, it must be recognized that vehicle repeatability in the SHED test, particularly with vehicles operating on a relatively high volatility fuel, is not as good as a typical new certification vehicle. Since no replicate tests were conducted and several vehicles (blend and control) were identified as having higher than normal hot soak emissions, it will be difficult to draw any conclusions as to the effect of canister switching.

VI. RECOMMENDATIONS

Investigation of evaporative emissions from vehicle fleets provides valuable information for typical evaporative emissions. However, when using these fleets to look for small changes due to fuel, canister, and other items, it is quite conceivable that the variability of the vehicles and test procedures will overshadow any differences due to canister switching. If it is desirable to pursue additional research along these lines, SwRI has several suggestions that might be of interest.

1. Vehicle fleets are expensive to operate and it is not always possible to "piggy-back" emissions testing on a fleet test that is using the alcohol blend of interest. Previous work assignments have used synthetic blends to simulate gasoline and blend vapors in loading mini-canisters. Although these studies have provided useful information on loading and purging characteristics, it is difficult to relate these data to equivalent vehicle evaporative emissions. The desirable approach would be to have a bench scale system that would load and purge full-scale canisters using actual gasoline and blend vapors. The system could be used on a 24-hour basis to simulate mileage accumulation on many canisters simultaneously. It would also allow flexibility for testing canister capacity, as well as evaporative emission testing of the canisters on slave vehicles.

   Another advantage of this type of system is that various fuel blend formulations could be evaluated using various combinations of alcohols, co-solvents and gasoline. This system would allow investigation of azeotrope formation with alcohol-gasoline blends.

2. Using the aforementioned evaporative emission generator, it would be possible to conduct experiments that would provide a better understanding of azeotrope formation with various alcohol blend combinations. Vapor composition could be monitored for methanol, co-solvent, and detailed hydrocarbons to establish the relationship between vapor composition in a typical gas tank and those vapors adsorbed during normal and hot vehicle purges.

TABLE 4. DIURNAL CONTRIBUTION TO OVERALL SHED EMISSIONS FROM BLEND AND CONTROL VEHICLES WITH VARIOUS CANISTER COMBINATIONS

Vehicle Group	Fuel	Canister	SHED Emissions, % Diurnal
Blend	EM-601-F	Blend[a]	67
Control	EM-601-F	Control[a]	52
Blend	EM-601-F	Blend	72
Control	EM-601-F	Control	65
Blend	EM-601-F	Control[b]	42
Control	EM-601-F	Blend[b]	68
Blend	EM-620-F	Blend	31
Control	EM-620-F	Control	8
Blend	EM-620-F	Control	12
Control	EM-620-F	Blend	36

[a]Work Assignment 4, EPA Contract 68-03-3192
[b]Only four vehicles/canisters: 101, 102, 201, 202

TABLE 5. COMPARISON OF SHED EVAPORATIVE EMISSIONS FROM BLEND AND CONTROL VEHICLES WITH FUEL EM-601-F (9.1 psi RVP)

Vehicle	Canister	SHED Evaporative Emissions[b] Diurnal	Hot Soak	Total
Blend[a]	Blend	3.70	1.85	5.55
Control[a]	Control	1.31	1.19	2.50
Blend	Blend	3.10	1.20	4.30
Control	Control	2.07	1.10	3.17
Blend	Control	1.96	2.71	4.67
Control	Blend	2.44	1.17	3.61

[a]Work Assignment 4, EPA Contract 68-03-3192.
[b]Numbers given are average of tests on two vehicles (101 and 102 with the blend or 201 and 202 with the control fuel used for mileage accumulation.)

TABLE 6. SHED EVAPORATIVE EMISSION RATES AND CANISTER WEIGHT GAIN, SUMMARY FOR VEHICLES, 101, 102, 201 AND 202 WITH EM-620-F

		SHED Evaporative Emissions,g			Canister Weight Gain,g		
Vehicle	Run	Diurnal	Hot Soak	Total	Diurnal	Hot Soak	Total
101	1	8.63	2.14	10.77	21.2	16.7	37.9
	2	11.84	1.27	13.11	20.9	14.2	35.1
	3	7.51	1.45	8.96	22.9	13.0	35.9
	Avg	9.33	1.62	10.95	21.7	14.6	36.3
	S.D.	2.25	0.46	2.08	1.1	1.9	1.4
102	1	10.76	32.90	43.66	18.4	34.0	52.4
	2	12.72	11.92	24.60	18.2	29.9	48.1
	3	13.18	17.10	30.30	17.5	31.3	48.8
	Avg	12.22	20.64	32.85	18.0	31.7	49.8
	S.D.	1.29	10.93	9.78	0.5	2.1	2.3
201	1	7.38	1.26	8.64	17.3	22.9	40.2
	2	7.99	1.05	9.04	17.5	15.7	33.2
	3	6.54	17.41	23.95	21.3	18.2	39.5
	Avg	7.30	6.57	13.88	18.7	18.9	37.6
	S.D.	0.73	9.39	8.73	2.3	3.7	3.9
202	1	10.41	6.39	16.80	15.0	28.9	43.9
	2	6.38	16.94	23.32	18.8	31.6	50.4
	3	15.67	30.06	45.73	10.0	32.3	42.3
	Avg	10.82	17.80	28.62	14.6	30.9	45.5
	S.D.	4.66	11.86	15.17	4.4	1.8	4.3

TABLE 7. SUMMARY OF CANISTER WEIGHTS DURING SHED TESTING ON VEHICLES 101, 102, 201 AND 202 WITH EM-620-F

		Canister Weight, g							
Vehicle	Run	Before Diurnal	After Diurnal	Diurnal Gain	Before Hot Soak	After Hot Soak	Hot Soak Gain	FTP Losses[a]	Canister[b]
101	1	814.6	835.8	21.2	793.7	809.0	16.7	42.1	+5.6
	2	816.4	837.3	20.9	793.6	807.8	14.2	43.7	+8.6
	3	807.2	830.1	22.9	789.9	802.9	13.0	40.2	+4.3
	Avg	812.7	834.4	21.7	792.4	806.6	14.6	42.0	+6.1
	S.D.	4.9	3.8	1.1	2.2	3.2	1.9	1.8	2.2
102	1	812.8	831.2	18.4	795.2	829.2	34.0	36.0	-16.4
	2	814.9	833.1	18.2	794.4	824.3	29.9	38.7	-9.4
	3	815.4	832.9	17.5	792.4	823.7	31.3	40.5	-8.3
	Avg	814.4	832.4	18.0	794.0	825.7	31.7	38.4	-11.3
	S.D.	1.4	1.0	0.5	1.4	3.0	2.1	2.3	4.4
201	1	787.4	804.7	17.3	767.9	790.8	22.9	36.8	-3.4
	2	788.2	805.7	17.5	767.9	783.6	15.7	37.8	+4.6
	3	781.2	802.5	21.3	766.8	785.0	18.2	35.7	-3.8
	Avg	785.6	804.3	18.7	767.5	786.5	18.9	36.8	-0.9
	S.D.	3.8	1.6	2.3	0.6	3.8	3.7	1.1	4.7
202	1	793.0	808.0	15.0	770.0	798.9	28.9	38.0	-5.9
	2	790.0	808.8	18.8	775.4	807.0	31.6	33.4	-17.0
	3	802.9	812.9	10.0	774.8	807.1	32.3	38.1	-4.2
	Avg	795.3	809.9	14.6	773.4	804.3	30.9	36.5	-9.0
	S.D.	6.8	2.6	4.4	3.0	4.7	1.8	2.7	7.0

[a]FTP losses = (weight of canister after diurnal) - (weight of canister before SHED hot soak)
[b]Canister = (weight of canister before diurnal) - (weight of canister after SHED hot soak)

TABLE 8. SUMMARY OF REFERENCE WEIGHT CHECKS ON BALANCE USED FOR CANISTER WEIGHING

		2 lb Weight (907.4g)			1 lb Weight (453.6g)		
Vehicle	Run	Actual	Observed	% change	Actual	Observed	% change
101	1	907.4	907.6	0.02	453.6	453.8	0.04
	2	907.4	907.6	0.02	453.6	453.8	0.04
	3	907.4	907.6	0.02	453.6	453.8	0.04
	Avg	907.4	907.6	0.02	453.6	453.8	0.04
102	1	907.4	907.6	0.02	453.6	453.8	0.04
	2	907.4	907.6	0.02	453.6	453.8	0.04
	3	907.4	907.6	0.02	453.6	453.8	0.04
	Avg	907.4	907.6	0.02	453.6	453.8	0.04
201	1	907.4	907.6	0.02	453.6	453.8	0.04
	2	907.4	907.6	0.02	453.6	453.8	0.04
	3	907.4	907.6	0.02	453.6	453.8	0.04
	Avg	907.4	907.6	0.02	453.6	453.6	0.04
202	1	907.4	907.6	0.02	453.6	453.8	0.04
	2	907.4	907.6	0.02	453.6	453.8	0.04
	3	907.4	907.6	0.02	453.6	453.8	0.04
	Avg	907.4	907.6	0.02	453.6	453.8	0.04

% change defined as $\frac{\text{(Observed-Actual)}}{\text{Actual}} \times 100\%$