CONTRACT NO. A832-153
FINAL REPORT
JANUARY 1992

Quantification of Evaporative Running Loss Emissions From Gasoline-Powered Passenger Cars in California

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

AIR RESOURCES BOARD
Research Division

QUANTIFICATION OF EVAPORATIVE RUNNING LOSS EMISSIONS FROM GASOLINE-POWERED PASSENGER CARS IN CALIFORNIA

Final Report
Contract No. A832-153

Prepared for:

Research Division
California Air Resources Board
1800 15th Street
Sacramento, CA 95814

Submitted by:

Automotive Testing Laboratories, Inc.
32152 State Road #2
New Carlisle, IN 46552

Prepared by:

Dennis McClement
Principal Investigator

January 1992

Abstract

The purpose of this effort was to collect Running Loss Emission Data on a representative cross section of in-use, light duty passenger cars to support the development of California specific emission factors. Forty randomly procured vehicles were tested. A total of 104 sequences were performed. Tests were performed using fuels at 7.5 and 9.0 psi RVP, 105 and 95°F, and the LA-4 and NYCC driving sequences. The study found that the evaporative running loss emissions were strongly dependent on the age of the vehicles, fuel vapor pressure and ambient temperatures. Substantial differences in running loss emissions were found between these factors. Vehicles were less sensitive to driving cycle when considered on a mass per unit time basis.

Acknowledgement

This report was submitted in fulfillment of CARB Agreement No. A832-153, "Quantification of Evaporative Running Loss Emissions from Gasoline-Powered Passenger Cars in California", under the sponsorship of the California Air Resources Board. Work was completed as of December, 1990.

Table of Contents

List of Figures

List of Tables

I. Summary and Conclusion

The purpose of this study was to add to the available data relating to Hydrocarbon (HC) evaporative emissions during vehicle operation (Running Losses), specifically under those conditions most frequently encountered in southern California.

Running Loss data collected to date by the Federal Environmental Protection Agency (EPA) has focused on national climatic conditions, nationally available fuels, and a projection of the future in-use fleet. The data in this study is intended to supplement the federal Running Loss data base to permit the preparation of an improved model of current mobile source Running Loss emissions for California. In particular, this study includes additional data on older vehicles, with lower RVP fuels, and at higher ambient temperatures, as appropriate to the current Los Angeles in-use vehicle population.

Five 1982-1989 carbureted vehicles were randomly procured from the Los Angeles in-use vehicle fleet and transported to Automotive Testing Laboratories' (ATL) New Carlisle, Indiana site. Five matching vehicles were procured from the South Bend, Indiana vehicle population. Running Loss evaporative emission tests were performed under the same test conditions on all ten vehicles. The results of these tests were examined to determine if a systematic difference existed between the two groups of vehicles. No trend was noted in this very limited sample. This is the expected result with knowledge that the same evaporative emission test procedures and standards applied to both Federal and California vehicles of this vintage. Based on the results of these tests, it was decided to use 49 state certified vehicles procured in South Bend for the balance of the program. This permitted a substantial increase in the number of tests and the number of vehicles tested for the total program.

A total of 105 tests were performed on forty vehicles. Tests were performed at ambient temperatures of 80, 95, and 105 °F. Fuel vapor pressures of 7.5 and 9.0 psi were studied. Two driving cycles were included – the LA-4 used for new vehicle certification and the much lower average speed New York City Cycle (NYCC). A baseline test was performed on all vehicles using the 9.0 fuel, the LA-4 driving cycle and the 95 °F ambient temperature. Based on the results of the baseline test, additional sequences were performed on some vehicles at selected combinations of test parameters.

Two mechanisms of Running Loss emission generation were noted in previous test programs. Properly operating, current technology vehicles generally emit a constant, low level of HC early in each Running Loss test. This has been labelled "Type I" emissions in this study. As test severity increases, these same low level vehicles will display a transition into a high rate of HC emission generation. This mode of operation has been labelled "Type II" emissions. Type II emissions have been attributed to an overload of the evaporative control system, or "canister saturation". When the evaporative emission charcoal canister is filled to capacity, vehicle behavior approaches that of a vehicle with a missing or defective evaporative emission control system. Consideration of these two modes of operation in any Running Loss evaporative emission model is strongly recommended.

Development of Running Loss Emission Factors was not an objective of this study. Nevertheless, a number of trends were observed as the data was generated. These observations were not subjected to rigorous statistical validation.

Average Running Loss emission levels increase with vehicle age. Older vehicles approach vehicles which were certified prior to implementation of evaporative emission controls. No differences were noted between the 10 year old (less stringent) and the 20 year old (Precontrol) vehicles studied in this program. This is attributed to the deterioration of the 10 year old systems. Properly operating, current technology vehicles displayed Running Loss emissions orders of magnitude lower than the older vehicles when operating in the Type I regime. The new technology vehicles approached the uncontrolled vehicles following transition to Type II operation.

Fuel tank temperatures observed during the test affects the time of transition between Type I and Type II operation, and therefore overall emission levels. Actual fuel temperature profiles were developed on a test track for most of the vehicles tested in this program. The ten vehicle California vs. Federal comparison program was performed using reasonable fleet average numbers. As the time at which transition from Type I to Type II occurs greatly effects total emissions during a test, development of accurate fuel tank temperature profiles and control of the temperatures during the test is critical to accurate development of Running Loss emission factors.

Other factors noted to affect Running Loss emissions were driving cycle, ambient temperature and fuel vapor pressure. The effects of each factor were much less significant when the vehicle was in the Type I mode of operation. Following breakthrough to Type II operation, Running Losses are strongly dependent on fuel and ambient temperature. Response to driving cycle, and resultant average speed, was mixed. Some vehicles displayed higher emissions during the LA-4 cycles while others were higher during the NYCC testing. This was attributed to differences in the evaporative emission controls systems developed by the vehicle manufacturer to permit compliance with current Diurnal and Hot Soak evaporative emissions standards. Purge strategy, in particular, is sensitive to average vehicle speed, and could substantially affect running loss emissions observed during the NYCC cycle.

II. Recommendations

Examination of running loss concepts, the EPA data, and the ARB data shows that running loss emissions can be affected by:

- Vehicle:
  - Individual
  - Model year
  - Status (Problem-free, malfunctioning, or tampered)
  - Fuel metering type (carbureted or fuel-injected)
- RVP
- Temperature:
  - Ambient
  - Tank
- Driving pattern
- Duration of driving (time).

Running Losses can be characterized by two regimes of emissions with distinctly different behaviors. The behaviors which are exhibited for a specific vehicle being exposed to a specific condition depend on the attributes of the vehicle and the severity of the condition. The two behavior regimes are:

> Type I Running Losses, which dominate at mild conditions. These emissions tend to be low level emissions which are weakly dependent on RVP, temperature, driving pattern, and time.
>
> Type II Running Losses, dominate at severe conditions. These emissions are high level emissions that are strongly dependent on vehicle, RVP, temperature, driving pattern, and time.

Several techniques or approaches should be considered when analyzing the data to create models of the individual vehicle emissions:

- Analyze EPA and ARB data together to get more information to provide a more seamless view of trends.
- Consider separately vehicle groups that could have different running loss responses:
  - Model year groups,
  - Fuel metering type, and
  - Status (problem-free, malfunctioning, tampered);
- Consider cumulative emissions at each bag so that the final model will have the time dependence of emissions.
- Split the reported cumulative emissions at each bag into Type I and Type II Running Losses. Modeling of these two types of emissions should be done separately to avoid smearing of the RVP and temperature effects.
- Regress the data against vehicle, RVP, temperature, and the RVP/temperature interactions. Interactions, especially the RVP/temperature interaction, should be aggressively pursued, since they can have a large effect on predicted emissions.
- If possible, after performing initial data analyses, attempts should be made to combine vehicle groups that respond similarly to RVP and temperature. This will increase the amount of data in each regression and provide a more reliable model.

Once the individual vehicle models have been developed, they can be combined to create the vehicle population model. Special approaches for this last stage to be considered should include:

- Ensure the representativeness of vehicles whose results are to be averaged. Include low-emitters as well as high emitters. The results which are chosen to be averaged will have a large effect on the final model, since Running Losses appear to be very vehicle-dependent.
- Determine separate fleet average vehicle models for the Type I and Type II Running Loss emissions.
- Combine the models to create the complete running loss vehicle population model.

III. Procedures

The methods that were used to collect data will be summarized in this section. First, vehicle procurement procedures will be outlined. The methodology used to determine realistic fuel tank temperature targets for the dynamometer test, including the specific dyno driving cycles, will then be discussed. The test fuels and temperatures used will be reviewed as the matrix of tests performed is displayed. The section will conclude with a synopsis of the measurement hardware, test procedures, and quality assurance program.

A. Test Vehicle Selection

Evaporative Running Loss emissions are affected by the conventional evaporative emission control devices present on the vehicle. The California in-use vehicle population includes a measurable fraction of cars and trucks produced prior to the introduction of evaporative emission controls to the new vehicle fleet, and increasingly greater fractions produced at each succeeding control level. The earliest evaporative emission control device test procedures utilized Carbon traps at suspected sources of evaporative losses. At the next level of stringency, the entire vehicle was sealed in an enclosure (a Sealed Housing for Evaporative Determination, or SHED) to capture all vapors emitted from the vehicle. Finally, the permitted level of HC emissions during the SHED test was reduced from 6 grams to 2 grams. Four distinct technology groups are, accordingly, present in the California population: Pre-control, Carbon trap, 6 gram SHED, and 2 gram SHED. Vehicles from each level of technology were included in this test program.

During EPA Emission Factors testing of current technology vehicles, differences related to fuel induction technologies were noted in both exhaust and evaporative emissions. This program includes examples of carbureted, throttle body injection, and port fuel injection technology vehicles to insure representation of these factors.

California has historically led the nation in the implementation of vehicle emission control standards. While California required earlier introduction of evaporative controls, the same procedures and level of stringency applied to vehicles produced later for the rest of the nation (49 state vehicles). A limited program was performed to compare California certified vehicles to 49 state vehicles; the vehicle sample population therefore includes instances from both areas of the country. The California certified vehicle numbers are prefixed with the initials "ARB", the 49 state vehicles, procured from the South Bend, Indiana area are prefixed with the initials "SB".

Table 1 summarizes the vehicle sample population demographics. The six California certified vehicles were randomly procured in the Los Angeles area and transported to ATL's New Carlisle, Indiana facility for testing. The remaining thirty four test vehicles were randomly procured from the South Bend, Indiana vehicle population. Vehicle registration lists were used to perform random mailings to vehicle owners at both locations. The owners were supplied with a loaner, a full tank of gas, and a cash incentive for participation in the program. Each incoming vehicle was inspected to insure that the evaporative emission control system was not tampered and was representative of the in-use population.

Vehicles SB-1 through 5 were specifically selected to match the corresponding five vehicles procured in California. Each matched the model year, make, engine size, transmission and induction system of the corresponding California vehicle. Candidate vehicles for this group were selected from the South Bend registration list based on VIN. Mailings for the remaining 49 state vehicles were based on the model year and technology groups required.

One vehicle, SB-9, was disqualified from the program after initial testing. This vehicle, a 1970 VW Karmann Ghia, generated high levels of visible crankcase blowby emissions which could not be separated from evaporative emissions in the Running Loss enclosure.

Table 1.
Test Vehicle Technology Groupings

Fuel System	Model Years	Qty	Evap Control Technology	Source
Carbureted	1968-1970	5	PreControl	49 State
Carbureted	1972-1977	5	Canister	(1) California (4) 49 State
Carbureted	1978-1980	5	6g SHED	49 State
Carbureted	1982-1989	10	2g SHED	(5) California (5) 49 State
Multipoint FI	1982-1989	9	2g SHED	49 State
Throttle Body FI	1982-1989	6	2g SHED	49 State

B. Fuel Temperature Profiles

During new vehicle certification testing for Diurnal Evaporative emissions, external heat is applied to the vehicle fuel tank to achieve a fuel temperature rise of 60 to 84°F[1]. A number of studies performed at temperatures outside of the certification temperature envelope demonstrated the strong relationship between tank fuel temperatures and HC vapor generation. This temperature sensitivity was found to hold during Running Loss testing[2].

The first Running Loss tests performed by ATL for EPA used fixed fuel tank temperature profile targets for specific points during the Running Loss test. Later testing was performed using fuel temperature profiles which matched temperatures observed during operation of a similar vehicle on a closed test track. The pilot testing for this program was performed using the fixed EPA targets. Testing of vehicles after the pilot program (after ARB-6 and after SB-5) was based on fuel temperature profiles developed on a test track.

Track fuel temperature data was collected using a methodology which parallels dynamometer procedures. An in-tank, wetted fuel temperature thermocouple was installed in the test vehicle. The fuel tank was drained and filled to 40% capacity with 9.0 psi certification grade test fuel, and then soaked overnight at elevated temperature. An estimated temperature for the next days track run was used as a soak temperature. The vehicle was moved outdoors as the time for the track run approached, and the fuel temperature was allowed to stabilize at ambient temperature. The fuel temperature was required to match the ambient out door temperature on the track within ±3°F at the start of the run.

Test vehicles were towed or pushed to a staging area adjacent to the test track prior to the start of a run. Each track run was started from a "cold start" using standard dynamometer engine starting procedures. The vehicle engine remained off until the vehicle was ready to enter the prescribed driving schedule.

---

1 Code of Federal Regulations (CFR), Title 40, Part 86, Subpart B § 86.133-78 Diurnal breathing loss test.

2 U.S. Environmental Protection Agency, Office of Mobile Sources, "Running Loss Test Program: Interim Results," November 30, 1988, updated November 1989.

The lead vehicle was equipped with a fifth wheel, tach generator and driver's aid. The driver's aid was loaded with a predrawn speed-time schedule matching the speed-time trace which was to be followed during Running Loss dynamometer testing. The fifth wheel and tach generator provided a real-time speed signal to the driver's aid. The vehicle operator actuated the driving schedule, and then controlled the vehicle accelerator and brakes to cause the vehicle speed to follow the prescribed trace at the prescribed time. A second vehicle operator steered the vehicle while the first operator watched the driving schedule.

One or more test vehicles followed the lead vehicle as it was operated on the track. Hand held thermocouple readouts were used to monitor fuel temperatures during driving. Fuel temperatures were recorded in each test vehicle at times corresponding to the sampling points during a dynamometer test. The initial temperature was subtracted from each reading to develop a dynamometer fuel temperature profile.

The base Running Loss dynamometer driving schedule is three replications of the 1372 second LA-4[3] driving schedule. This results in slightly more than one hour of continuous vehicle operation. Each LA-4 is divided into two segments - 0 to 505 seconds and 505 to 1372 seconds. During a dynamometer test, exhaust emission samples in each segment are collected in separate Constant Volume Sampler (CVS) sample bags. Running Loss results are referred to by the six corresponding exhaust emission "bag" results. Fuel temperature profiles are defined at the end of each of the six bag sample points. Test vehicles are operated on a test track using three repetitions of the LA-4 driving schedule. Fuel temperatures are recorded at the end of each bag sample point. The rise observed during the track runs are translated to targets to be achieved at the six sample points during the dynamometer runs.

Exhaust emissions during a 598 second New York City Cycle (NYCC) test are collected in a single CVS bag. The NYCC driving schedule is repeated six times during a Running Loss test to achieve a nominal one hour of continuous vehicle operation. The initial track temperature studies[4] demonstrated that fuel temperatures are more driven by the length of vehicle operation time than by average speed of the driving cycle, given similar ambient test conditions for both test runs. Dynamometer temperature profiles for NYCC

---

3 CFR, Title 40, Part 86, Appendix I - Urban Dynamometer Schedules, (a) Light-Duty Vehicles

4 Automotive Testing Laboratories, Inc. "Driving Cycle Effect on Tank Fuel Temperature" Final Report, Work Assignment 1-6, EPA Contract 68-03-3380, July 29, 1988.

testing, therefore, are derived from LA-4 track results by interpolating actual segment times. For example, the 598 second and 1196 second dynamometer fuel temperature targets for a NYCC test are linearly interpolated from the 505 and 1372 LA-4 track temperature results. Targets for other driving cycles can be similarly derived.

Figures 1 and 2 graphically display the relative speeds of LA-4 and NYCC driving cycles. The nominal 7.5 mile distance traveled during an LA-4 results in an average speed of 19.7 mph. The standard Federal Test Procedure (FTP) includes two repetitions of the first 505 seconds of the LA-4, resulting in an average speed of 21.3 mph. The 1.18 nominal distance of the NYCC schedule results in an average speed of 7.1 mph. The NYCC also includes a higher fraction of idle time than the LA-4. A listing of the NYCC speed/time schedule is included in Table 2.

Temperature profiles were drawn from the existing data base[5,6] whenever similar vehicles were procured for this program. Most of the older technology vehicles required track temperatures for the Running Loss test. This data was collected on the Bendix Automotive Proving Grounds in New Carlisle, Indiana. Primary criteria for valid track data collection include pavement temperatures more than 25°F above ambient, wind speeds less than 10 mph, and opaque cloud cover less than 10%. These criteria were developed during EPA testing to correspond to ozone exceedence conditions.

C. <u>Test Fuels</u>

Two levels of fuel RVP were tested. Both fuels were prepared from Howell Hydrocarbon EEE certification grade fuel meeting 40 CFR 86.113-90 specifications. Nominal 9.0 psi tests were performed using the EEE fuel as received. Nominal 7.5 psi tests were performed using EEE fuel which had been weathered with compressed air until a 7.5 psi vapor pressure was achieved. Both fuels were drawn from laboratory stocks over the extended duration of the testing program. Several batches of each fuel were used during this time. No oxygenates were present in either fuel type.

---

5 Automotive Testing Laboratories, Inc. "Determination of Tank Fuel Temperature Excursions", Final Report, Work Assignment 0-1, EPA Contract 68-C9-0027, January 9, 1990.

6 Automotive Testing Laboratories, Inc. "Determination of Tank Fuel Temperature Excursions", Final Report, Work Assignment 1-1, EPA Contract 68-C9-0027, November 13, 1990.

Figure 1
LA-4 Driving Schedule

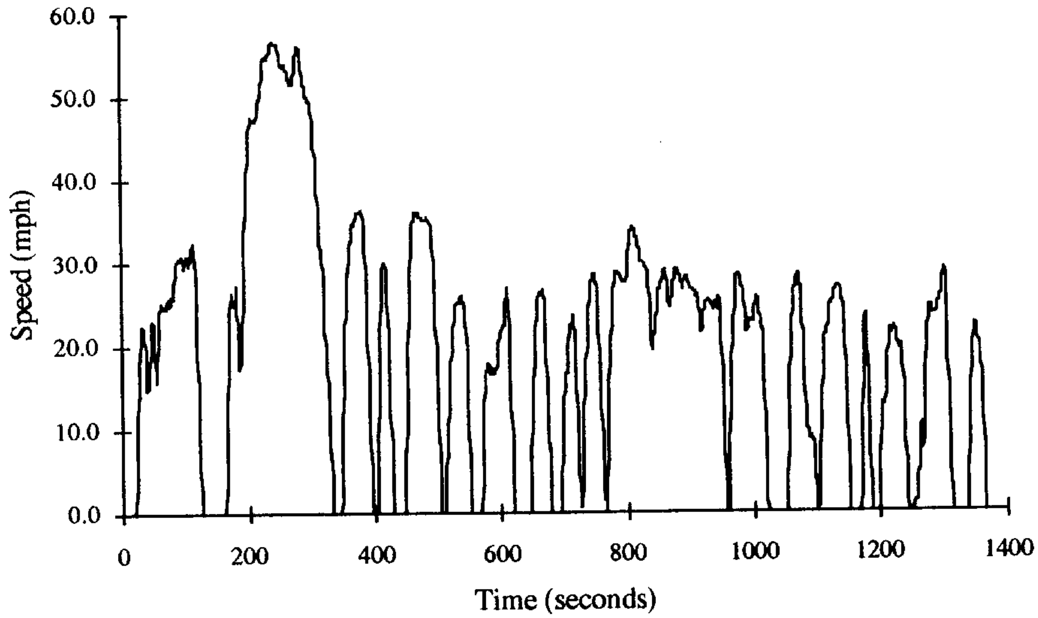


Figure 2.
NYCC Driving Schedule

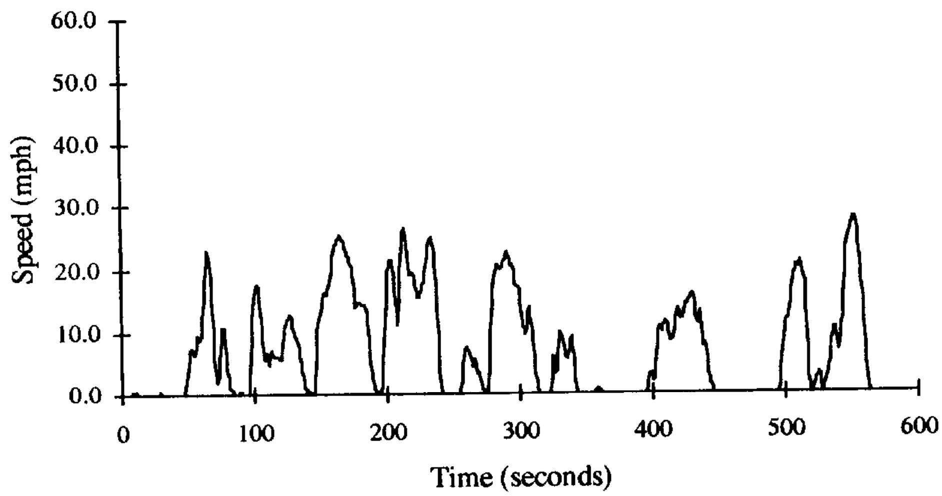


Table 2.
New York City Cycle (NYCC) Speed vs. Time Schedule

time	mph	time	mph	time	mph	time	mph	time	mph	time	mph
1	0.0	51	7.0	101	17.4	151	15.1	201	20.7	251	0.0
2	0.0	52	7.6	102	17.3	152	16.2	202	21.4	252	0.0
3	0.0	53	7.6	103	17.2	153	15.9	203	21.4	253	0.0
4	0.0	54	6.2	104	15.1	154	16.0	204	20.5	254	0.0
5	0.0	55	6.4	105	11.2	155	16.8	205	19.0	255	0.2
6	0.0	56	7.6	106	8.6	156	17.5	206	16.7	256	2.0
7	0.0	57	9.5	107	5.9	157	18.0	207	13.1	257	4.5
8	0.3	58	8.9	108	5.4	158	19.6	208	11.2	258	6.4
9	0.0	59	8.6	109	6.8	159	21.7	209	14.9	259	7.2
10	0.2	60	9.6	110	6.9	160	23.1	210	19.8	260	7.6
11	0.3	61	12.4	111	4.8	161	23.7	211	23.8	261	7.2
12	0.0	62	15.0	112	5.7	162	24.1	212	25.7	262	6.6
13	0.0	63	17.8	113	7.1	163	24.5	213	26.2	263	6.5
14	0.0	64	21.0	114	6.8	164	25.0	214	26.4	264	5.1
15	0.0	65	22.9	115	5.9	165	25.2	215	23.3	265	4.4
16	0.0	66	21.7	116	6.0	166	24.6	216	19.6	266	5.5
17	0.0	67	18.2	117	6.0	167	24.3	217	18.9	267	3.0
18	0.0	68	14.5	118	5.9	168	23.3	218	19.3	268	3.4
19	0.0	69	10.2	119	5.6	169	22.7	219	19.4	269	3.0
20	0.0	70	5.6	120	5.5	170	22.1	220	18.5	270	2.9
21	0.0	71	2.5	121	7.2	171	21.6	221	17.5	271	1.3
22	0.0	72	2.1	122	9.9	172	21.1	222	16.4	272	0.8
23	0.0	73	3.1	123	10.8	173	20.3	223	15.6	273	0.3
24	0.0	74	5.7	124	11.4	174	19.2	224	15.6	274	0.0
25	0.0	75	9.0	125	11.9	175	17.0	225	16.0	275	0.0
26	0.0	76	10.8	126	12.1	176	13.9	226	16.8	276	0.3
27	0.0	77	10.8	127	12.6	177	14.1	227	17.5	277	4.7
28	0.1	78	9.5	128	12.3	178	14.6	228	18.0	278	9.7
29	0.2	79	6.5	129	10.6	179	14.6	229	19.6	279	13.9
30	0.0	80	3.9	130	9.9	180	14.5	230	21.7	280	16.7
31	0.0	81	2.6	131	9.4	181	14.4	231	23.5	281	19.1
32	0.0	82	1.0	132	8.9	182	14.2	232	24.6	282	20.5
33	0.0	83	0.8	133	7.6	183	14.2	233	25.0	283	20.5
34	0.0	84	0.1	134	6.1	184	13.2	234	24.3	284	19.7
35	0.0	85	0.0	135	5.0	185	11.5	235	23.1	285	19.9
36	0.0	86	0.0	136	3.7	186	8.4	236	20.7	286	20.4
37	0.0	87	0.0	137	2.6	187	5.5	237	17.2	287	20.9
38	0.0	88	0.0	138	1.0	188	3.7	238	13.5	288	21.4
39	0.0	89	0.3	139	0.8	189	2.9	239	9.2	289	21.9
40	0.0	90	0.2	140	0.1	190	1.3	240	3.3	290	22.4
41	0.0	91	0.0	141	0.4	191	0.8	241	0.0	291	22.1
42	0.0	92	0.0	142	0.2	192	0.3	242	0.0	292	21.4
43	0.0	93	0.0	143	0.0	193	0.1	243	0.0	293	20.8
44	0.0	94	0.0	144	0.0	194	0.1	244	0.0	294	20.3
45	0.0	95	0.0	145	0.0	195	0.0	245	0.0	295	20.5
46	0.0	96	0.0	146	1.3	196	1.3	246	0.0	296	19.3
47	0.0	97	2.7	147	6.0	197	3.9	247	0.0	297	17.3
48	0.4	98	8.3	148	10.2	198	9.9	248	0.0	298	17.1
49	2.8	99	12.4	149	12.1	199	15.9	249	0.0	299	16.7
50	5.6	100	15.7	150	13.8	200	19.3	250	0.0	300	14.3

Table 2 (cont).
New York City Cycle (NYCC) Speed vs. Time Schedule

time	mph	time	mph	time	mph	time	mph	time	mph	time	mph
301	11.9	351	0.0	401	2.3	451	0.0	501	11.8	551	27.7
302	10.7	352	0.0	402	4.6	452	0.0	502	12.2	552	27.6
303	10.2	353	0.0	403	7.8	453	0.1	503	14.3	553	27.3
304	9.4	354	0.0	404	9.9	454	0.0	504	16.0	554	25.7
305	10.6	355	0.0	405	10.7	455	0.0	505	17.8	555	23.3
306	12.8	356	0.1	406	10.2	456	0.0	506	18.6	556	20.6
307	13.7	357	0.3	407	10.1	457	0.0	507	19.6	557	17.8
308	12.3	358	0.5	408	10.7	458	0.0	508	20.2	558	14.9
309	10.4	359	0.6	409	10.9	459	0.0	509	19.9	559	11.3
310	8.6	360	0.5	410	11.4	460	0.0	510	19.7	560	7.4
311	5.5	361	0.2	411	11.1	461	0.0	511	20.8	561	4.6
312	3.2	362	0.0	412	10.0	462	0.0	512	21.0	562	1.7
313	2.0	363	0.0	413	8.8	463	0.0	513	18.8	563	0.7
314	0.6	364	0.0	414	8.2	464	0.0	514	17.6	564	0.0
315	0.0	365	0.0	415	8.6	465	0.0	515	13.0	565	0.0
316	0.0	366	0.0	416	10.2	466	0.0	516	7.5	566	0.0
317	0.0	367	0.0	417	11.8	467	0.0	517	2.9	567	0.0
318	0.0	368	0.1	418	13.0	468	0.0	518	0.8	568	0.0
319	0.0	369	0.0	419	13.3	469	0.0	519	0.0	569	0.0
320	0.0	370	0.0	420	12.8	470	0.0	520	0.2	570	0.0
321	0.0	371	0.0	421	11.7	471	0.0	521	0.7	571	0.0
322	0.0	372	0.1	422	11.7	472	0.0	522	1.4	572	0.0
323	0.0	373	0.1	423	12.4	473	0.0	523	2.3	573	0.0
324	2.5	374	0.0	424	13.7	474	0.0	524	2.7	574	0.0
325	6.1	375	0.0	425	14.4	475	0.0	525	3.0	575	0.0
326	5.5	376	0.0	426	14.3	476	0.0	526	2.7	576	0.0
327	3.2	377	0.0	427	14.7	477	0.0	527	1.2	577	0.0
328	3.6	378	0.0	428	15.1	478	0.0	528	0.1	578	0.0
329	6.1	379	0.0	429	15.3	479	0.0	529	0.7	579	0.0
330	9.1	380	0.0	430	15.8	480	0.0	530	1.8	580	0.0
331	9.8	381	0.0	431	14.5	481	0.0	531	3.1	581	0.0
332	8.6	382	0.0	432	12.2	482	0.0	532	3.9	582	0.0
333	6.8	383	0.0	433	11.1	483	0.0	533	5.3	583	0.0
334	5.9	384	0.0	434	12.0	484	0.0	534	7.8	584	0.0
335	5.6	385	0.0	435	13.1	485	0.0	535	9.7	585	0.0
336	6.0	386	0.0	436	12.2	486	0.0	536	10.3	586	0.0
337	7.2	387	0.0	437	8.9	487	0.0	537	10.2	587	0.0
338	8.4	388	0.0	438	7.7	488	0.0	538	9.4	588	0.0
339	9.3	389	0.0	439	7.6	489	0.0	539	7.1	589	0.0
340	7.6	390	0.0	440	8.0	490	0.0	540	6.8	590	0.0
341	5.5	391	0.0	441	5.5	491	0.0	541	8.9	591	0.0
342	2.5	392	0.0	442	3.3	492	0.0	542	10.6	592	0.0
343	0.1	393	0.0	443	2.4	493	0.0	543	11.9	593	0.0
344	0.0	394	0.0	444	1.4	494	0.0	544	15.5	594	0.0
345	0.0	395	0.0	445	0.6	495	0.0	545	19.6	595	0.0
346	0.0	396	0.2	446	0.0	496	1.0	546	22.8	596	0.0
347	0.0	397	1.6	447	0.0	497	4.1	547	25.1	597	0.0
348	0.0	398	3.0	448	0.0	498	7.4	548	26.0	598	0.0
349	0.0	399	3.0	449	0.0	499	10.2	549	26.7		
350	0.0	400	2.1	450	0.0	500	11.3	550	27.3		

D. Test Matrix

Two ambient temperature levels were included in the initial test matrix - 95° and 105 °F. Baseline tests on each vehicle were performed at 95° F using 9.0 psi fuel and the LA-4 driving cycle. The results of the baseline test were reviewed with the program sponsor and additional test combinations were selected. Further tests were normally not performed on vehicles which emitted 2.0 or less grams during the baseline sequence. A total of eight test combinations exist with two driving cycles, two temperature levels and two fuel rvp levels. Table 3 lists the number of tests performed with each combination. Included in these counts are three sequences performed using a modified proposed ARB Running Loss sequence, three tests performed after repairs, and one test performed at an ambient temperature of 80°F..

Table 3.
Test Type Distribution

	LA-4 Tests			NYCC Tests		
Temp	9.0	7.5	Total	9.0	7.5	Total
105	9	5	14	16	10	26
95	47	4	51	9	4	13
80	1	0	1	0	0	0
Totals:	57	9	66	25	14	39

E. Running Loss Measurement Hardware

Evaporative Running Loss Emissions tests were performed in a SHED enclosure equipped with a conventional twin roll dynamometer. The enclosed SHED volume (5700 ft^3) was approximately twice the capacity of a conventional evaporative emission enclosure. Combustion air was provided directly to the operating vehicle engine from outside of the enclosure. Engine exhaust was routed from the vehicle to the outside of the enclosure into a Constant Volume Sampler (CVS). The base enclosure was fabricated to meet new vehicle certification specifications for evaporative emission testing, including standard temperature measurements, Hydrocarbon analyzers, and materials. Additional air handling and cooling was added to manage the additional heat load from the operating vehicle and to permit testing at elevated temperatures (95-105°F). Additional analyzers (CO and CO_2) were added to monitor the enclosure for vehicle exhaust leaks during the test.

An industry standard Clayton ECE-50 twin roll dynamometer was located inside enclosure. The direct drive variable flywheel equipped dyno was capable of inertia selection from 1000 to 6500 pounds in 125 pound increments. A 50 horsepower capacity power absorption unit (PAU) was used to simulate road horsepower load. A Clayton Road Load Power Control (RLPC) automatic load controller was used to control the PAU.

A Beckman 400 Hydrocarbon analyzer was used to measure HC levels inside the enclosure. The FID analyzer was operated on 60%He/40%H_2 and zero grade air. Calibrations were performed using gases traceable to EPA Ann Arbor standards and a gas divider. Named working gases were used to calibrate the analyzer before and after each reading.

Enclosure cooling was provided by three air conditioners equipped with freon to water heat exchanger/condensers. The three small air conditioning units were staged at 1/2° intervals. The lower individual capacity of the three AC units reduced the breathing of the enclosure which results from the large temperature cycles observed with a single, high capacity unit. A standard 5300 CFM Hartzell fan was used to provide under hood cooling. A variable speed blower was used for under vehicle and fuel tank temperature control. Fuel heating was provided by a convection heater/blower whose outlet was directed at the bottom surface of the vehicle fuel tank. Fuel heating was controlled automatically by a programmable temperature achiever. Electric resistance heaters were used to elevate the enclosure to 95° or 105°F for the start of a test. The heaters were shut off at the start of the test. Vehicle heat, with cooling as required, was used to maintain the elevated temperatures inside the enclosure.

The Running Loss enclosure was fabricated with metal sheets and Tedlar doors and windows. Average ambient temperature probes were located midway along the interior long walls. Enclosure propane background, calibration, and retention checks were performed in accordance with CFR requirements[7], except the standard for the retention test were a maximum loss of 5% in a one hour period at 95° with all fans, air conditioners and blowers running.

---

7 CFR, Title 40, Part 86, Subpart B § 86.117-78 Evaporative Emission Enclosure Calibrations.

Running Loss evaporative emissions were calculated using standard CFR procedures for Diurnal Emissions[8]:

$$M_{HC} = \frac{.208(12+2.33)}{10^4} V_n \left[\frac{C_{HCf}P_{Bf}}{T_f} - \frac{C_{HCi}P_{Bi}}{T_i} \right]$$

where

M_{HC} = grams HC Running Loss Emissions

V_n = Net enclosure volume

C_{HCi},C_{HCf} = Initial and Final HC Concentration (ppmC)

P_{Bi},P_{Bf} = Initial and Final Barometric Pressure (in hg)

T_i,T_f = Initial and Final Enclosure Temperature (°R)

The end of each preceding sample period is considered the "initial" reading while the end of the period is considered the "final" reading. Initial SHED ambient temperature, pressure and HC levels expressed as ppmC were subtracted from end of phase HC, pressure and temperature readings to result in net HC mass emissions during the test period. The net HC emissions during the six phases were summed to yield total grams per test. Dyno roll revolutions were measured during each phase to permit calculation of distance traveled during the phase. Running Loss results are reported in terms of net and cumulative grams per phase, and in grams per mile. Grams per mile values were computed by dividing grams per phase by distance in that phase and by dividing cumulative grams by cumulative distance.

Exhaust samples were collected with an AESI six bag Constant Volume Sampler. Emissions were measured using an ATL fabricated bench and commercial analyzers. CFR specifications applied to the sample handling and analyzer train. Exhaust gas measurements included Total Hydrocarbon (THC), Carbon Monoxide (CO), Carbon Dioxide (CO_2), and Oxides of Nitrogen (NO_x). Fuel economy was calculated using the carbon balance technique specified in the CFR. Because of procedural differences, exhaust emissions measured during a Running Loss test <u>cannot</u> be treated as true FTP results; but

---

8 CFR, Title 40, Part 86, Subpart B § 86.143-78 Calculations, evaporative emissions.

the relationship between exhaust emissions and canister loading/extended vehicle operation may be of interest to the emission modeler. Results are reported as grams/mile per bag. No weighting for Cold Start/Hot Start operation was performed.

F. Running Loss Test procedures

Results of multiple evaporative tests on a vehicle may be affected by canister loading from previous tests. A canister normalization procedure was developed to minimize this effect by providing a common starting point for each test. Initially, each vehicle received a fuel tank 40% fill with fresh 9.0 psi fuel. An LA-4 preconditioning run was then performed, followed by a one hour hot soak with the vehicle hood down and key off. A second LA-4 test was then performed, again followed by a one hour hot soak. The canister was removed from the vehicle at the end of the second hot soak and weighed. The canister weight at the end of this sequence (the "Normalized Weight") was used as the initial weight for all subsequent tests.

Preconditioning for each test was begun with a drain and 40% refuel with fresh test fuel. At the same time, the vehicle canister was removed and weighed. The canister weight was adjusted by purge with room air or load with Butane until it was within 2 grams of the normalized weight previously determined for that vehicle. The canister was reinstalled immediately before a single LA-4 prep, which was followed by an overnight soak at the temperature specified for the upcoming Running Loss test.

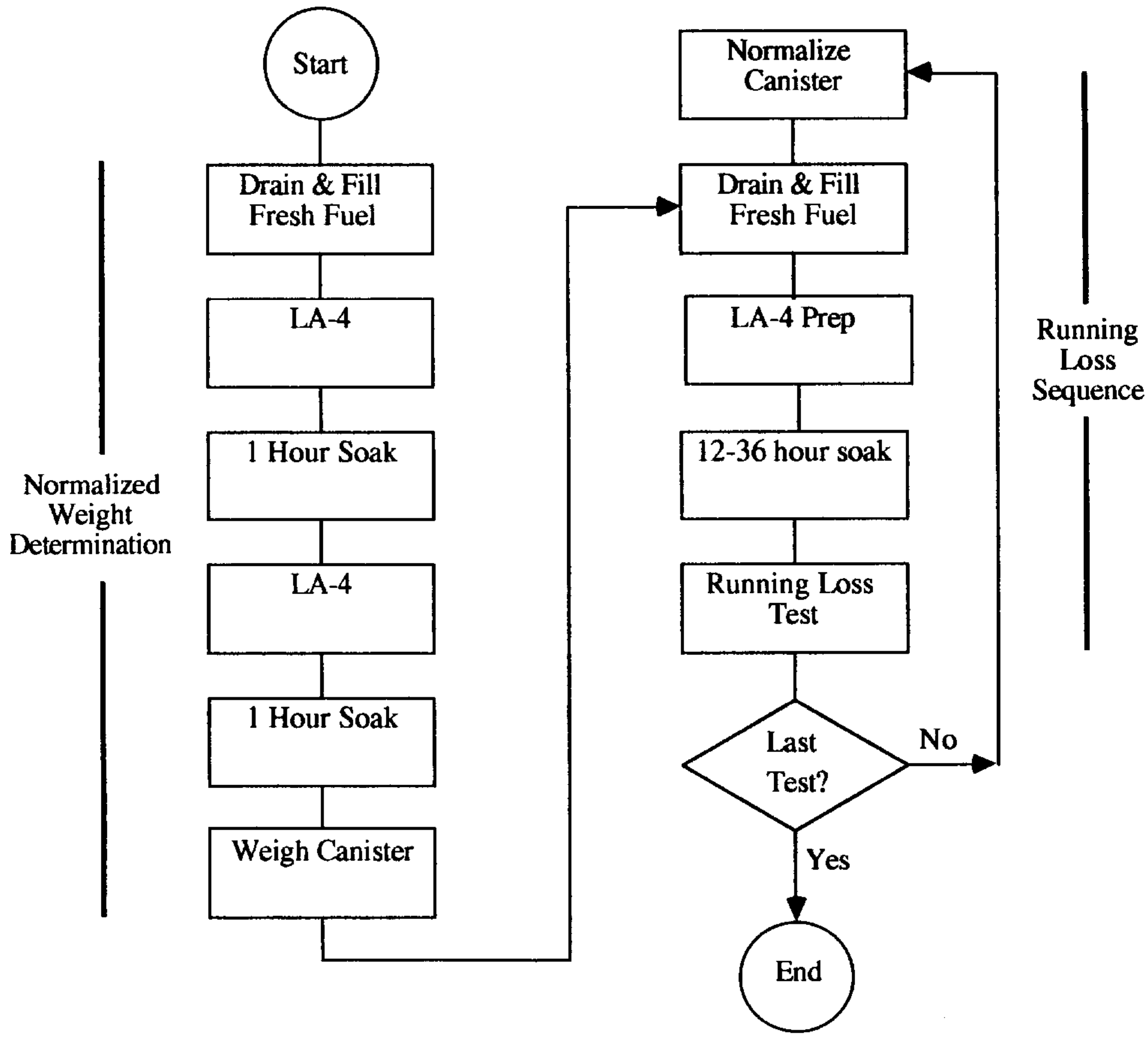
Following overnight soak, the vehicle was pushed into the Running Loss enclosure for the cold start test. A duct was connected to the vehicle air cleaner inlet to supply combustion air from outside of the enclosure. A separate inlet was provided for the vehicle air pump/pulse air system, if present. Vehicle exhaust was ducted out of the enclosure to a Constant Volume Sampler (CVS). Probes were routed to suspected sources of HC emissions; typically the gas cap, the evaporative charcoal canister, the roll over valve, and the fuel drain. The individual probes were attached to a four way valve controlled remotely by the instrument operator from outside the enclosure. Sample was pumped from the four way valve directly to a Beckman 400 Flame Ionization Detector (FID) analyzer. This was not a "point source" system as no dilution was applied. Mass measurements could not be computed with this system. The probes were used as diagnostic "sniffers" to identify relatively "high" and "low" source(s) of Running Loss emissions. Mass Running Loss emissions were computed directly from the HC levels observed in the fixed volume enclosure. Following vehicle hook up, the enclosure was sealed and the temperature was stabilized at the required level for the start of the Running Loss test.

The Running Loss test began when the vehicle engine was started. The driving schedule was activated, initial HC levels in the sealed enclosure were recorded, and CVS exhaust emission bag sampling was initiated. The vehicle was operated through the first 505 seconds of the driving schedule, a nominal distance of 3.59 miles (Bag #1). Enclosure HC levels were noted and the exhaust CVS sample was then switched to a second sample collection bag. At the end of 1372 seconds, CVS exhaust bag sampling ended but the vehicle remained at idle. Following 120 ± 30 seconds of idle, enclosure HC levels were recorded (Bag #2). A second repetition of the LA-4 was then begun. A third CVS exhaust emission sample bag (Bag #3) was selected and the vehicle was operated through the first 505 seconds of the second LA-4. Sampling continued with vehicle operation through the end of the second LA-4, and the vehicle again entered a two minute idle period (Bag #4). The test was completed with a third LA-4 (Bag #5 and #6). No idle followed the third repetition. The final Running Loss HC reading was taken at the 1372 second point of the final LA-4.

NYCC tests were simply six repetitions of the 10 minute driving cycle, each followed by two minutes at idle. The initial reading was taken at the start of each cycle, the final reading at the end of the 2 minute idle period corresponding to the beginning of the next repetition. The sixth cycle did not include the final two minute idle period, but ended simply at the end of the ten minute CVS sample period. A standard LA-4 preconditioning cycle was used for the NYCC Running Loss tests.

Figure 3. provides an overview of the canister normalization and Running Loss sequence.

Figure 3.
Canister Normalization and Running Loss Sequence



G. Quality Assurance

A rigorous Quality Assurance system applied to all procedures used to collect data for this program. All specifications meet or exceed CFR requirements for new vehicle certification. Extensions for the Running Loss procedures and hardware parallel those for standard evaporative emissions. Strip charts and raw data collected during each test sequence were collected in packets. The contents of each packet were reduced and independently reviewed to insure data validity. Daily, weekly, and monthly calibrations and verifications were similarly scrutinized. A summary of routine calibration checks is displayed in Table 4.

Table 4.
QC Checks

Daily

Item	Procedure	Limits
CVS	Propane Recovery	±2% of injected mass
	Dilution Air	<10 ppm HC & CO
Dilute Bench	Leak Check	Recovery of known gas bag injection ±1 %fs.
	Manifold and Instrument pressures and flows.	Exact
NOx Converter	Converter Efficiency	between 95% and 100%
Data Acquisition System	DVM vs Computer	max diff of ±0.5 % fs.
Gas Cylinders	Remaining Pressure	>300 psi remaining
FID	FID Fuel, FID air and sample pressure	exact
	HC Hang up	zero air bag injection <1 ppm
Dynamometer	strobe	46.3 ± 0.5 mph

Weekly

Analyzer Curve Verification	Gas Divider	smaller of ± 1% fs and ± 2% of point.
	Leak Check cylinder	± 1 % fs
	Span cylinder	± 0.5 % fs
Dynamometer	Roll down each weight	smaller of ±1 sec and ± 1 AHP
Temperature Probes	Low and high standard	± 1°F

Monthly

Propane Retention	Recover known mass of propane	± 4% recover < 5% loss/1 hour.

Initial and As Required by Verifications

CVS Calibration	LFE	40 CFR 86.119-90
Dynamometer	4 point roll down	±1 second/±1 AHP

IV. Results

Specific descriptions of the vehicles tested and the results obtained will be presented in this section of the report. Detailed results, presented in Appendices to the report, will be described. The results of a brief comparison of California and 49 State certified vehicles with respect to running losses will be presented. The section will be concluded with a presentation of results on vehicles which were tested at more than one level of the experimental factors in this study.

A. Test Vehicle Descriptions

Forty vehicles were procured and tested in this program. Table 5, Test Vehicle Descriptions, identifies the particular vehicles procured by vehicle number, model year, make, model, engine size, and fuel delivery system. As described in Section I, specific procurement objectives for evaporative system control technology were a part of this program. The final column in Table 5 categorizes the vehicles by technology group. The test vehicle sample included instances of vehicles produced prior to the introduction of evaporative emission controls (precontrol), from the the first level of control technology (canister), the next level (6 g SHED), and the current standard (2 g SHED). The current standard (2 g SHED) vehicles additionally included a representative sample of Carbureted (Carb), Throttle Body Injection (TBI), and Port Fuel Injection (PFI) fuel delivery systems.

Both Federal and California regulators have introduced more stringent testing procedures for evaporative emissions control systems, including regulations for on-board control of refueling emissions, and the ability to control multi-day, extended Diurnal, and Running Loss emissions. Presumably, a fifth and/or sixth technology group will result from the changes required for vehicle manufacturers to bring their future vehicles into compliance with these new regulations.

Table 6 extends the vehicle descriptions with Vehicle Identification Numbers (VIN), exhaust emission Engine Family numbers, and Evaporative Emission Family numbers. These emission family identifications were not required on the earliest vehicles. Many of the stickers were missing or illegible with the intermediate aged vehicles. Every effort was made to locate and decipher any vehicle identification data on each test vehicle.

Table 5.
Test Vehicle Descriptions

Veh No.	Model Year	Make	Model	Engine Size	Fuel Induct	Evap Control Technology
ARB-1	83	Oldsmobile	Delta 88	5.0L	Carb	2 g SHED
ARB-2	83	Nissan	Pulsar	1.6L	Carb	2 g SHED
ARB-3	84	Oldsmobile	Cutlass	3.8L	Carb	2 g SHED
ARB-4	84	Ford	Escort	1.6L	Carb	2 g SHED
ARB-5	85	Plymouth	Voyager	2.6L	Carb	2 g SHED
ARB-6	76	Mercury	Monarch	4.1L	Carb	Canister
SB-1	83	Oldsmobile	Delta 88	5.0L	Carb	2 g SHED
SB-2	83	Nissan	Pulsar	1.6L	Carb	2 g SHED
SB-3	84	Oldsmobile	Cutlass	3.8L	Carb	2 g SHED
SB-4	84	Ford	Escort	1.6L	Carb	2 g SHED
SB-5	85	Plymouth	Voyager	2.6L	Carb	2 g SHED
SB-6	89	Ford	Probe	2.2L	PFI	2 g SHED
SB-7	89	Nissan	Sentra	1.6L	TBI	2 g SHED
SB-8	89	Pontiac	Grand Am	2.3L	PFI	2 g SHED
SB-10	79	Chevrolet	Caprice	5.0L	Carb	6 g SHED
SB-11	79	Toyota	Celica	2.2L	Carb	6 g SHED
SB-12	68	Chevrolet	Bel Air	5.0L	Carb	Pre Control
SB-13	74	Chevrolet	Nova	5.7L	Carb	Canister
SB-14	80	Oldsmobile	Cutlass	4.3L	Carb	6 g SHED
SB-15	89	Dodge	Colt	1.5L	TBI	2 g SHED
SB-16	68	Rambler	American	3.8L	Carb	Pre Control
SB-17	86	Ford	Tempo	2.3L	TBI	2 g SHED
SB-18	89	Mazda	626	2.2L	PFI	2 g SHED
SB-19	87	Mercury	Marquis	5.0L	PFI	2 g SHED
SB-20	89	Buick	Skylark	3.3L	PFI	2 g SHED
SB-21	88	Buick	Skyhawk	2.0L	TBI	2 g SHED
SB-22	85	Ford	TBird	2.3L	PFI	2 g SHED
SB-23	75	Plymouth	Duster	3.7L	Carb	Canister
SB-24	78	Plymouth	Horizon	1.7L	Carb	6 g SHED
SB-25	78	Mercury	Marquis	7.5L	Carb	6 g SHED
SB-26	70	Ford	Maverick	4.1L	Carb	Pre Control
SB-27	68	Chevrolet	Chevelle	5.0L	Carb	Pre Control
SB-28	85	Toyota	Camery	2.0L	PFI	2 g SHED
SB-29	69	Mercury	Montego	5.0L	Carb	Pre Control
SB-30	77	Ford	LTD	5.0L	Carb	Canister
SB-31	88	Honda	Honda	1.5L	TBI	2 g SHED
SB-32	85	VW	Quantum	1.8L	PFI	2 g SHED
SB-33	87	Nissan	Stanza	2.0L	PFI	2 g SHED
SB-34	76	Datsun	B-210	1.5L	Carb	Canister
SB-35	84	Pontiac	6000	2.5L	TBI	2 g SHED

Table 6.
Test Vehicle Identification Data

Veh No.	Model Year	Make	VIN	Engine Family	Evap Family
ARB-1	83	Olds	1G3AY69Y6DM892505	DG35.0W4ARA3	3B4-3B
ARB-2	83	Nissan	JNIMN24S4DM106818	DNS1.6V9FAC9	ECC-1A
ARB-3	84	Olds	1G3AR69A4ER320370	E4G3.8W2NEY5	4B3-4E
ARB-4	84	Ford	1FABP0945EW199714	EFM1.6V2GDC8	4CM
ARB-5	85	Plym	2P4FH41G2FR104831	FCR2.6T2BBK2	FCR-TS
ARB-6	76	Merc	F6W34L556541F	-	-
SB-1	83	Olds	1G3AY69Y6DM774793	D3G5.OV4ARA9	3B4-3A
SB-2	83	Nissan	JNIMN24S3DM124730	DNS1.6V2AAF2	CARB-2AV
SB-3	84	Olds	1G3AR69A4ER367267	E4G3.8V2NEYO	4B3-49
SB-4	84	Ford	1FABP0940EW301601	EFM1.6V2GDK7	-
SB-5	85	Plym	2P4FH41G0FR254419	FCR2.6V2AAB8	FCRTS
SB-6	89	Ford	1ZVBT20C4K5115578	KFM2.2V5F2FD	2.2L-9HB
SB-7	89	Nissa	1N4GB2155KC773378	KNS1.6V5FAF5	-
SB-8	89	Pont	1G2NE54D6KC763261	K2G2.3V8XENO	KAO-2G
SB-10	79	Chev	1N69G9J226178	-	-
SB-11	79	Toyota	RA42224740O	-	-
SB-12	68	Chev	156698F117850	-	-
SB-13	74	Chev	1Y69H4K141973	-	GM104-2
SB-14	80	Olds	3M69FAM573210	-	-
SB-15	89	Dodge	JB3CU24XXKUO91781	KMT1.5V5FF13	-
SB-16	68	Ramb	A8SO6OAZO7319	-	-
SB-17	86	Ford	2FABPZZXZGB112212	GFM2.5V5HCF6	6FM
SB-18	89	Mazda	JM1GD222OKI717O41	KTK2.2V5FFG2	-
SB-19	87	Merc	2MEBM75F8HX628046	HFM5.0V5HBFX	-
SB-20	89	Buick	1G4NC54N2KMO11864	K2G3.3V8JAW4	KBO-2F
SB-21	88	Buick	1G4JS51K6JK42O665	J1G2.OV5TDG1	JAO-1O
SB-22	85	Ford	1FABP46W3FH125856	FFM2.3V5FGK2	-
SB-23	75	Plym	VL29C5B335731	-	-
SB-24	78	Plym	ML44A8D242129	-	-
SB-25	78	Merc	F8Z66A643627F	-	-
SB-26	70	Ford	OK91L345561	-	-
SB-27	68	Chev	136678BZ14501	-	-
SB-28	85	Toyota	JT2SX16EOGO373156	GTY2.OV5FBB3	EV-E
SB-29	69	Merc	9HO7F616171	-	-
SB-30	77	Ford	F7B63F208106O	-	2CV4
SB-31	88	Honda	1HGED3554JAO4831O	JHN1.5V5FCF4	88FD
SB-32	85	VW	WVWGAO33XFEOOO987	FVW1.8V6FBF8	FVWBI
SB-33	87	Nissan	JN1HT2118HTO34889	HNS2.OV5FCF9	F14-2
SB-34	76	Datsun	HLB210174253	-	-
SB-35	84	Pont	ZGZAG19R9E1230143	EZG2.5V5TPG7	4AO-ZA

B. Detailed Program Result Listings

Detailed listings of individual vehicle test results are contained as Appendices to this report.

Appendix A displays the Running Loss related test results. Each vehicle test is identified with respect to vehicle number (Veh), nominal fuel RVP (Fuel), nominal ambient temperature (°F), test cycle (Cycle) and the date the test was performed (Date). Fuel tank temperature data during the test is displayed next. The early tests used nominal fuel temperature rise targets of +15 and +22 °F above ambient. Tests performed after SB-6 used bag by bag temperature targets developed on a test track. The actual fuel temperatures and the fuel targets are displayed for each bag of each test. The mass HC increase in each test phase is listed next (RL - grams / Phase). These readings are the net mass increase in the Running Loss enclosure during the specific phase. They are computed using the Diurnal HC density factor specified for conventional Diurnal Evaporative emissions. These net masses are accumulated through the test, and are reported in the next column (RL - grams/Cum). Net grams in a phase divided by actual distance traveled in that phase is reported next (RL - grams/mile/Phase). The table is concluded with cumulative running losses divided by cumulative distance traveled in the test (RL - grams/mile/Cum).

Appendix B lists the CVS bag exhaust emissions measured during each phase of each running loss test. The table begins with a repeat of the test identification data recorded in Appendix A. Next, NO_x, HC, CO_2, and CO emissions are reported on a grams per mile per bag basis. Fuel economy by the Carbon balance method concludes the table. No attempt to weight or combine individual bag results into standard Federal Test Procedure (FTP) weighted results has been made. The Running Loss test protocol does not include the FTP ten minute soak between bag 2 and bag 3. In addition, the procedures used to deliver combustion air into the Running Loss enclosure to the engine do not follow FTP procedures. The data is valid, however, as a measure of extended driving effects and with respect to changes in running loss evaporative emissions.

Appendix C completes the listing of results with details of the test cell conditions during the test and any comments related to the vehicle condition at the time of the test. The test identification data of Appendix A and B is again listed, followed by a tabulation of the wet and dry bulb temperature observed at the underhood cooling fan inlet (Temps - Dry and Wet per bag). Average barometric pressure during the test follows the temperature listings. The distance traveled during the test, as measured by dynamometer roll revolutions, follows the barometer reading. The table is concluded with relevant comments concerning the test.

C. Pilot Program Results

The initial program definition included a requirement that all test vehicles be certified to California specifications. A very limited demonstration program was performed to verify the essential equivalence of the California and 49 State in-use fleets with respect to running loss emissions. While California has implemented evaporative standards ahead of Federal regulations, the same procedures and standards have, with time, been applied to both regions.

Five current technology (2g SHED) carbureted vehicles were randomly procured from the Los Angeles area. Following inspection and acceptance at the Haagen-Smit Laboratory, the five vehicles were transported to ATL's New Carlisle, Indiana test facility. Baseline (9.0 psi fuel/95°/LA-4) tests were performed on each vehicle. The as-received fuel cap was found to be leaking on two of these vehicles. A second test was performed on each vehicle with gas caps that did not leak.

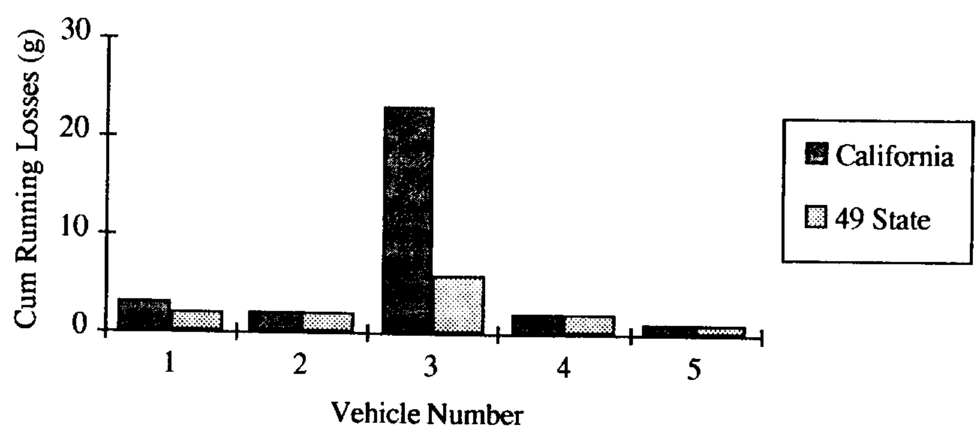
A vehicle registration list from South Bend, Indiana was scoured to locate vehicles as similar as possible to the California vehicles. Five vehicles which matched with respect to model year, make, model, and engine size were procured. Parallel baseline tests were performed on the same vehicles. Table 7 displays the results of these tests in terms of cumulative grams Running Losses. Figure 4 provides a graphic comparison of the results.

While this limited sample was not large enough to permit any broad statistical generalizations, the similarity of the two groups was sufficient to conclude that the California in-use fleet is not substantially cleaner than the Indiana in-use fleet with respect to unregulated Running Loss emissions.

Table 7.
Pilot Program Results

Veh	Year	Make	Model	Engine	Certification Group (Cum grams/mile) California	49 State
1	83	Oldsmobile	Delta 88	5.0L	2.57	1.59
2	83	Nissan	Pulsar	1.6L	1.83	1.63
3	84	Oldsmobile	Cutlass	3.8L	23.48	5.86
4	84	Ford	Escort	1.6L	2.25	2.02
5	85	Plymouth	Voyager	2.6L	1.33	1.17

Figure 4.
California/49 State Running Loss Comparison



D. Temperature/Fuel/Driving Cycle Effects

Twenty of the forty vehicles tested in this program were tested with only one combination of temperature/fuel/driving cycle, and were then returned to the owner. The remaining twenty vehicles received multiple tests at various combinations of the factors included in this program. Figure 5 displays the cumulative running losses for all tests on vehicles with more than one test. The results are presented in terms of cumulative grams at the end of bag 6. This representation is intended to assist the reader to visualize the differences between vehicles and the differences between tests on a given vehicle. Very large differences between vehicles were noted, as well as differences in response within a vehicle. In general terms, increased running losses were noted with increases in RVP and/or temperature. Differences between driving cycles is less clear cut, but, on average, the NYCC driving cycle usually resulted in higher total emissions than the LA-4 at the same level. On a grams/mile basis the NYCC on a given vehicle always exceeds the LA-4 because of the relatively low distance traveled during an NYCC test.

Figure 5.
Cumulative Running Losses
(Grams HC Per Test)

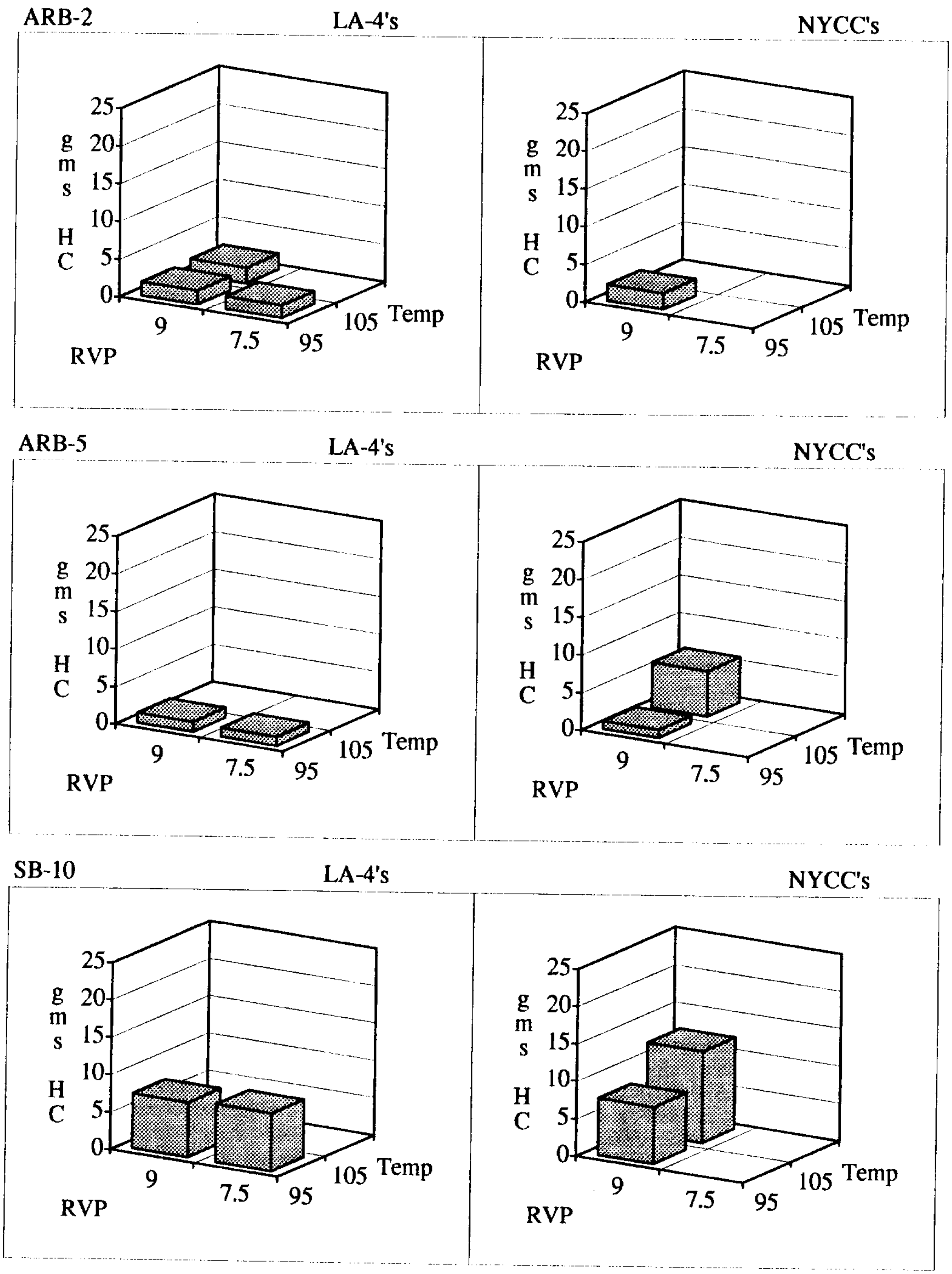


Figure 5.
Cumulative Running Losses
(Grams HC Per Test)

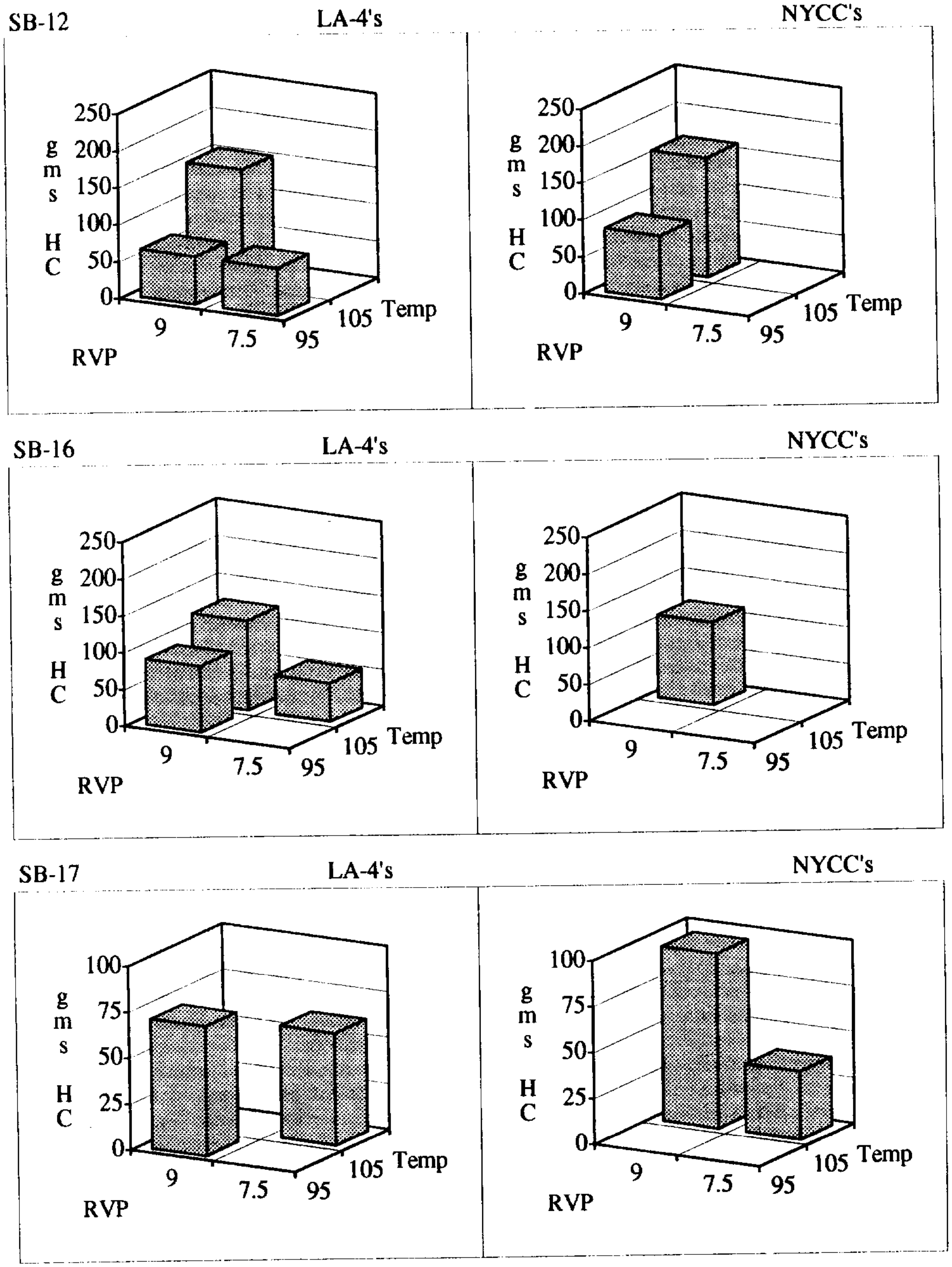


Figure 5.
Cumulative Running Losses
(Grams HC Per Test)

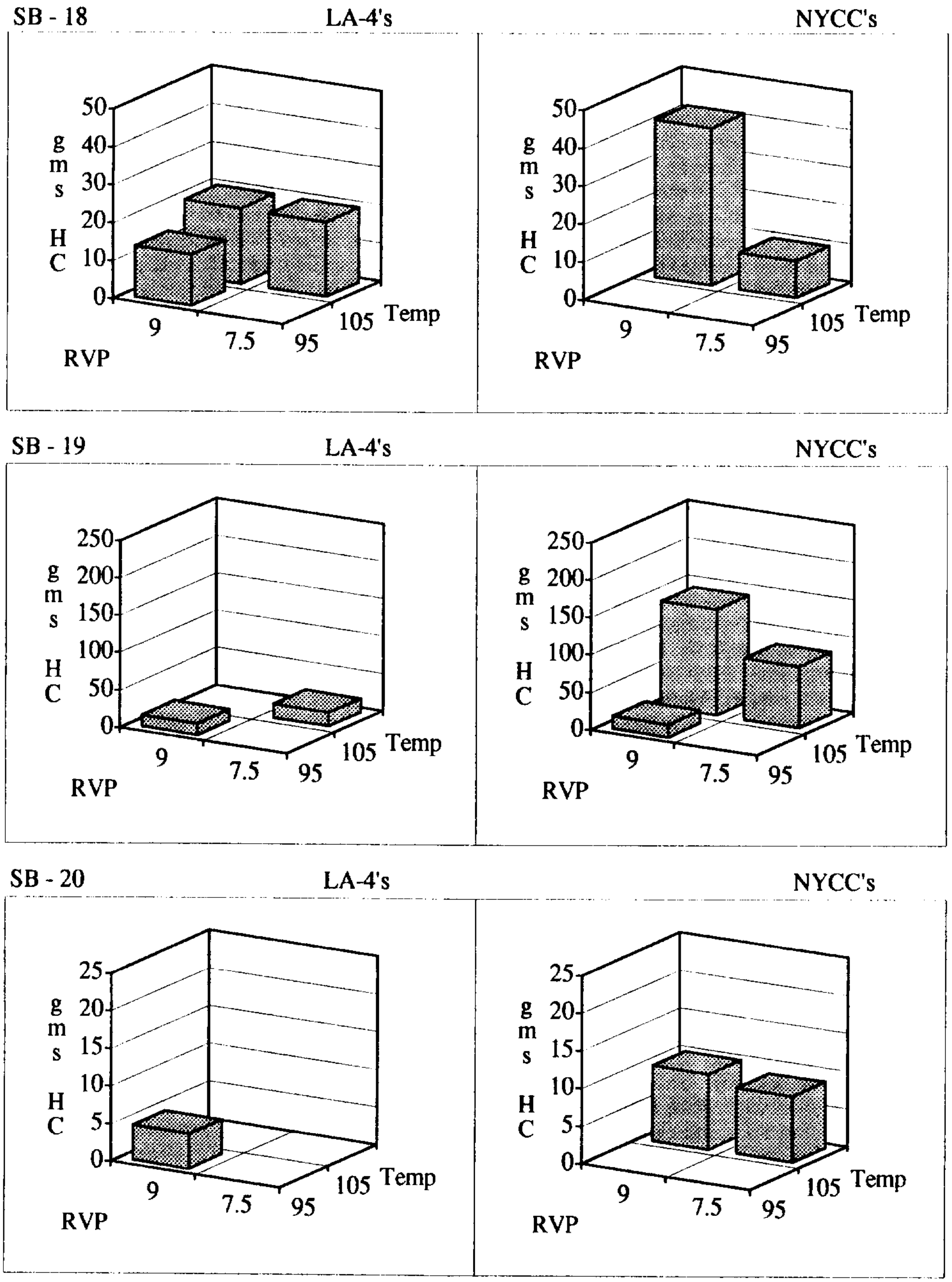


Figure 5.
Cumulative Running Losses
(Grams HC Per Test)

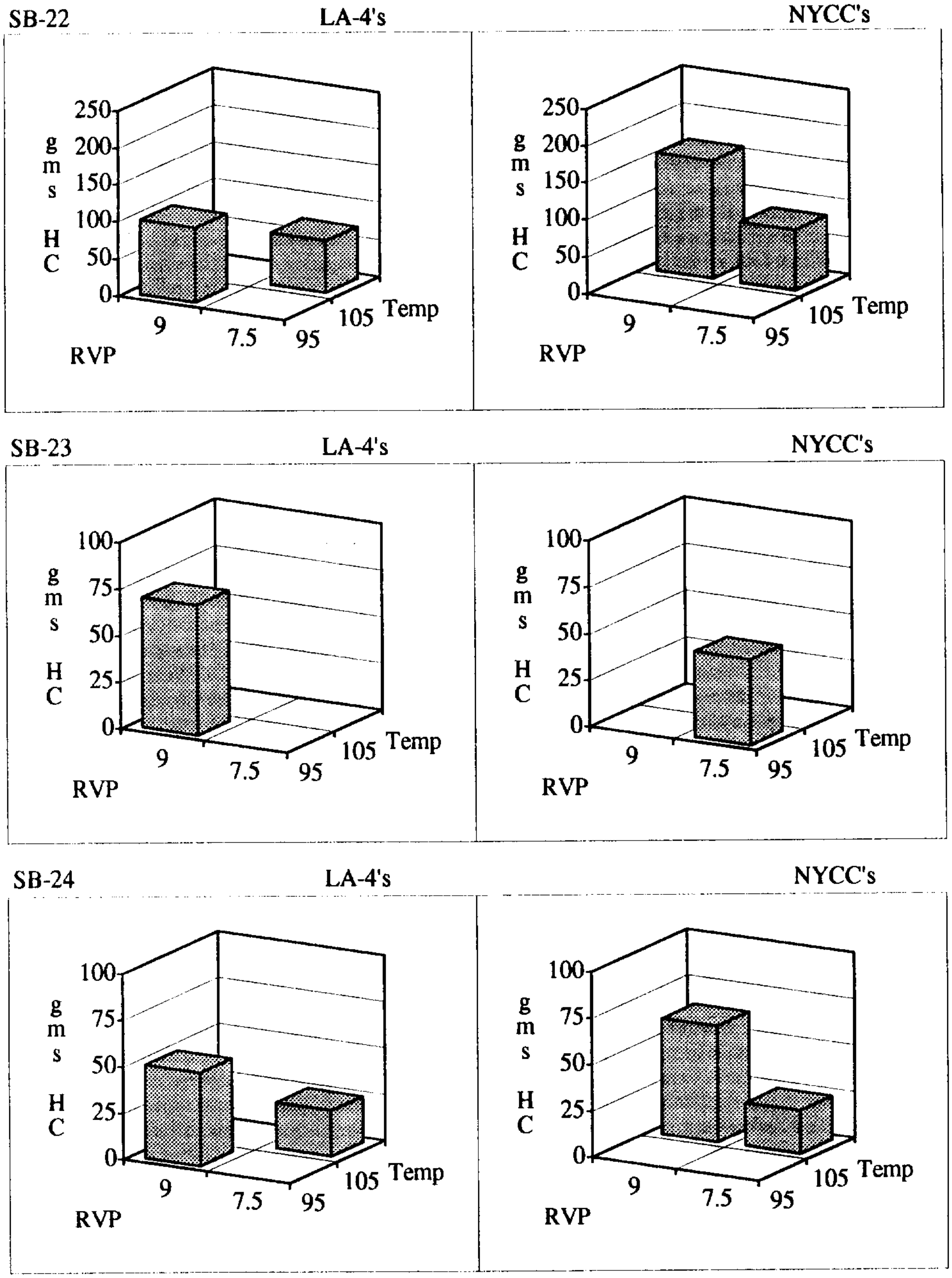


Figure 5.
Cumulative Running Losses
(Grams HC Per Test)

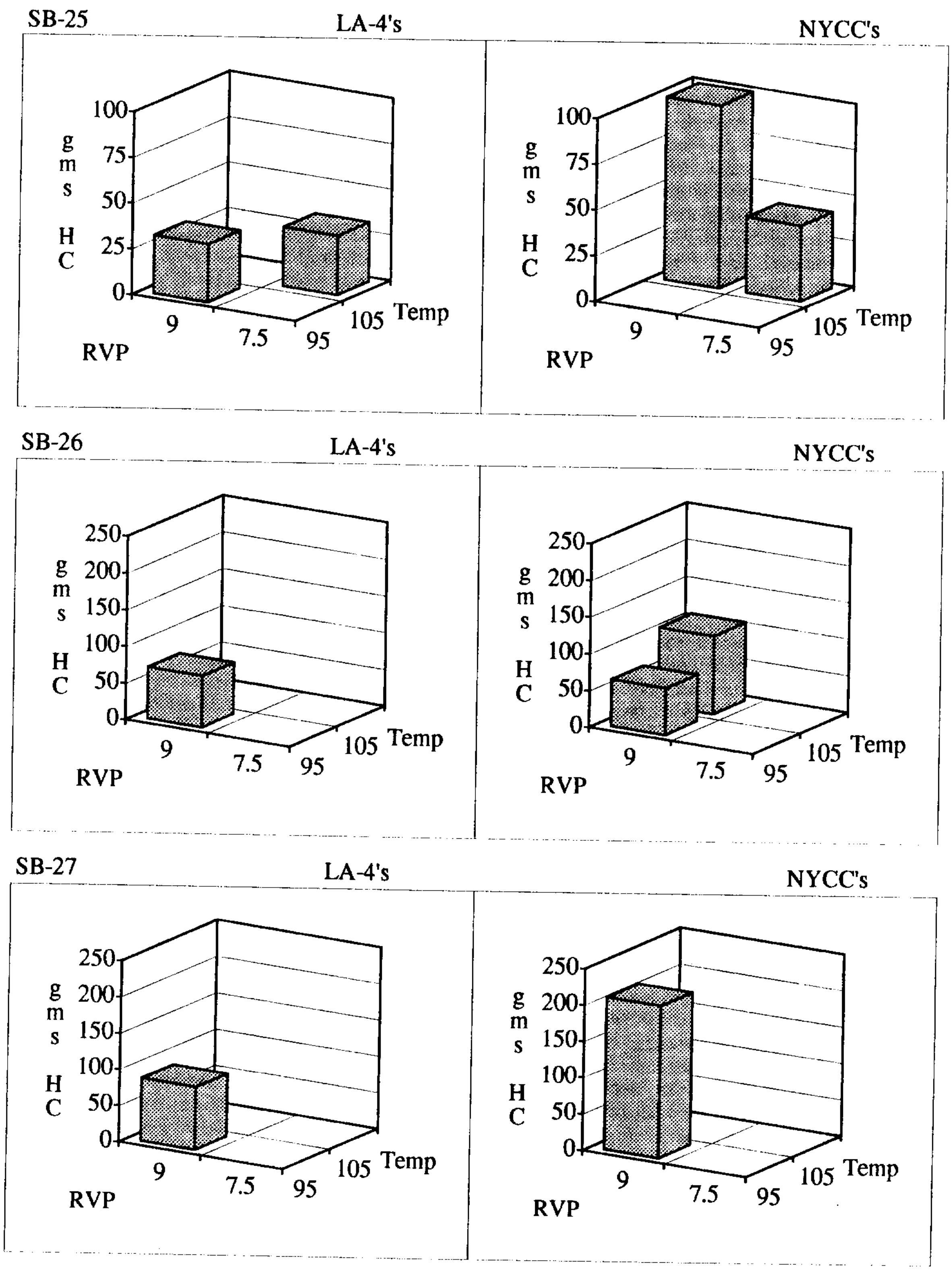


Figure 5.
Cumulative Running Losses
(Grams HC Per Test)

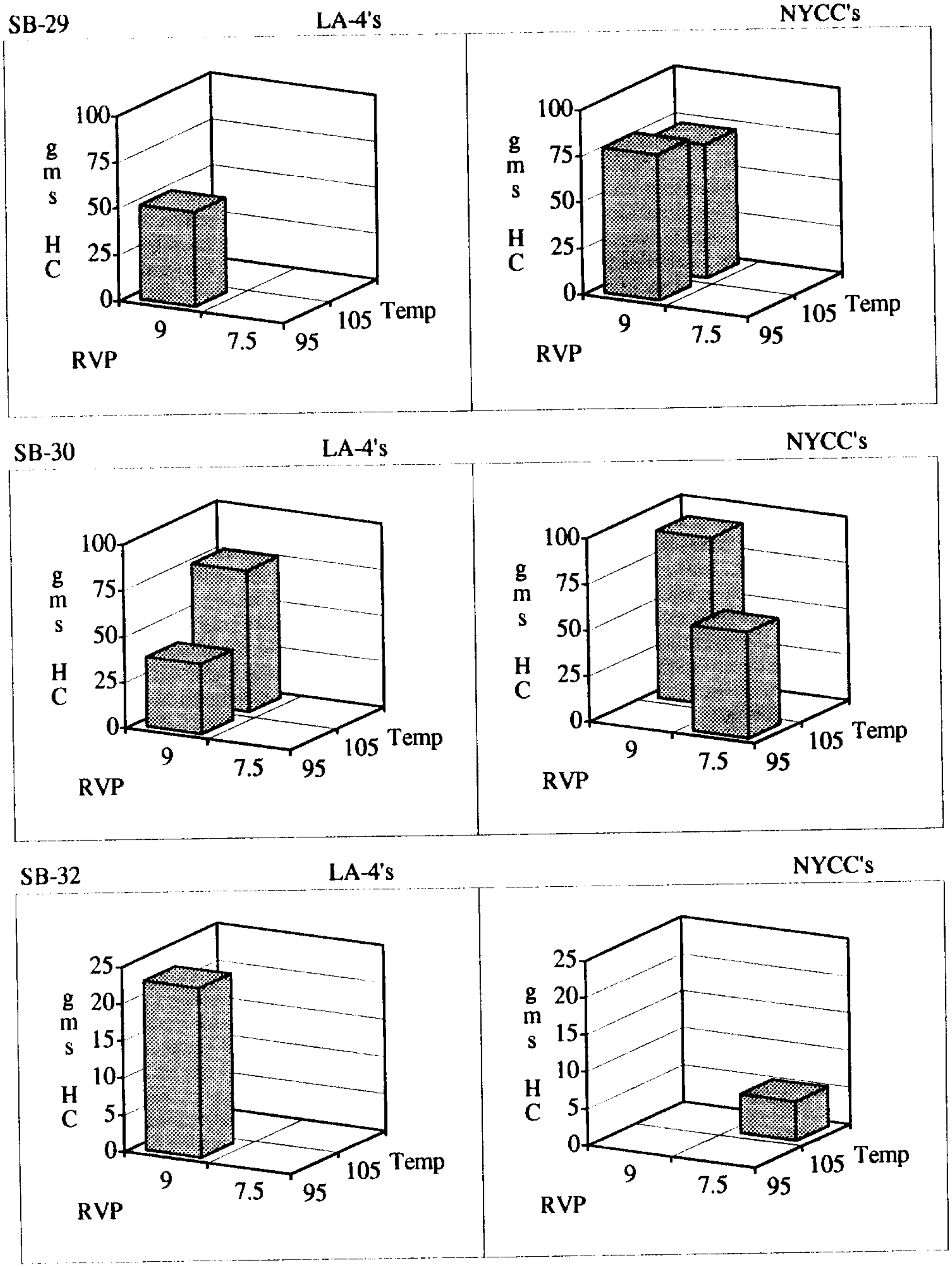
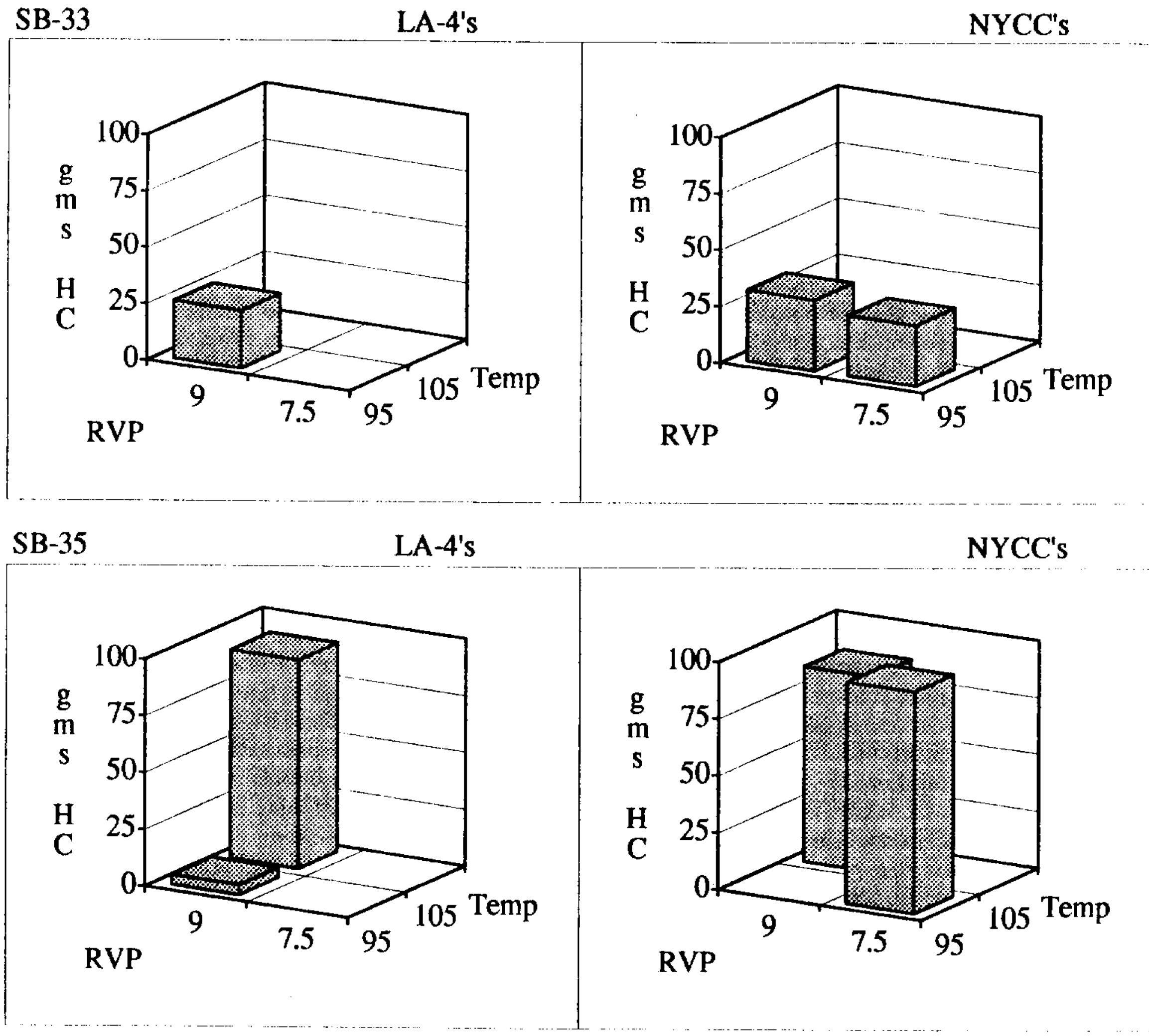


Figure 5.
Cumulative Running Losses
(Grams HC Per Test)



V. Analysis

Analysis of the results of this program will begin with a generalized examination of running loss emissions and related mechanisms, continue with a review of the EPA running loss data base, and conclude with an analysis of the results of this program, including recommendations concerning their application to the development of California specific running loss emission factors.

A. Running Loss Concepts

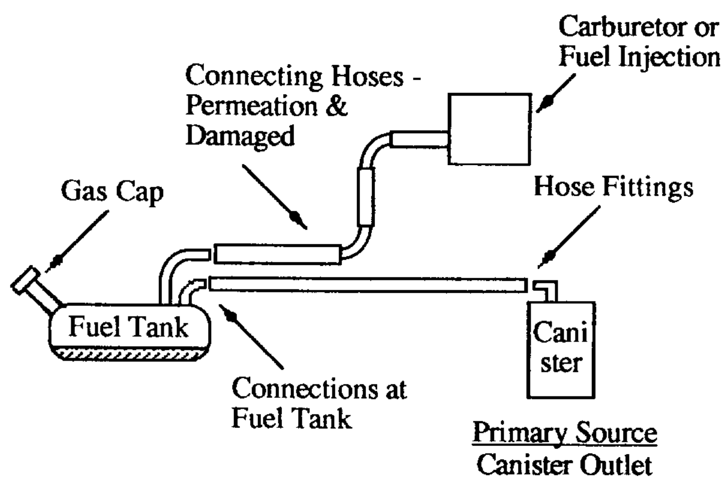
Before the ARB data collected in this test program and the EPA data are examined, a conceptual model of the generation of running losses by vehicles with evaporative emissions control systems will be developed. Since running loss emissions are non-linear in response to RVP, temperature, and driving pattern, such a model will demonstrate how these non-linearities arise. This running loss conceptual model will assist those who are developing models to better characterize test data on individual vehicles and to make better emissions predictions for the entire vehicle population.

The running loss model will be developed in three stages. Initially, the response of a single idealized vehicle will be considered. Certain simplifying assumptions concerning vehicle operation and evaporative emission control system operation will be made. Next, the example will be expanded to individual vehicles under less idealized conditions. Finally, the discussion will extend the behavior of individual vehicles to the in-use vehicle population. Understanding the assumptions associated with these extensions will help a model developer accurately portray fleet emissions.

To begin, a simplified steady state model of vehicle running losses will be developed. The initial model includes three components: a source of hydrocarbon vapors, a charcoal canister to store the vapors, and canister purge to eliminate stored vapors. The canister is assumed to be 100 per cent efficient in capturing generated vapors until its capacity is reached, and 0 per cent efficient afterwards. A constant canister purge rate is assumed. Finally, the rate of hydrocarbon generation is held at a constant level. These assumptions would correspond to a vehicle being operated at a constant speed after being warmed up to a stabilized temperature.

Hydrocarbon vapors are generated in different parts of the vehicle as it is operated. In fuel-injected vehicles, the primary source of HC vapors is the liquid fuel in the tank. As this fuel is heated and agitated during vehicle operation, vapors accumulate in the tank head space. These vapors are directed to a charcoal canister. In carbureted vehicles, additional hydrocarbon vapors may originate from the carburetor fuel bowl. In improperly maintained and/or older vehicles, each hose, line and connection may develop leaks. The gas cap, for example, may not seal properly after repeated loosening and tightening during fuel fills. Rubber hoses, particularly non-OEM replacements, will permeate fuel vapors with time. In this conceptual model, the specific source of vapors is not considered; all vapors are presented to the canister for later purge.

Figure 6.
Sources of HC Vapors



The magnitude of the HC generation rate depends primarily on fuel temperature and the fuel volatility. Environmental factors affecting tank fuel temperature include ambient temperature, pavement temperature, and the recent driving history of the vehicle. Design factors include fuel tank design, geometry, and position parameters. The volume of heated fuel bypassed and returned to the tank in high pressure fuel injection systems also significantly affects fuel temperature rises. For the purposes of this discussion, the severity of vehicle and environmental conditions will be defined in terms of fuel temperature and RVP. At more severe conditions, the hydrocarbon generation rate is higher.

The evaporative emissions control canister is purged by the operating engine. During purge, stored HC molecules are desorbed from the charcoal storage medium by a flow of ambient air. The canister vapor/air mixture is drawn into the engine by manifold vacuum, and is subsequently burned during engine operation. The purge rate depends on the purge strategy selected by the emission control system designer and the current operating mode of the vehicle. In general, higher purge rates are associated with hard accelerations and higher vehicle speeds. The Highway Fuel Economy Test cycle (HFET), for example, would generally result in increased canister purge. Vehicles ordinarily experience a lower canister purge when operated at idle and reduced speeds. The New York City Cycle (NYCC), for example, usually results in less purge than other testing modes.

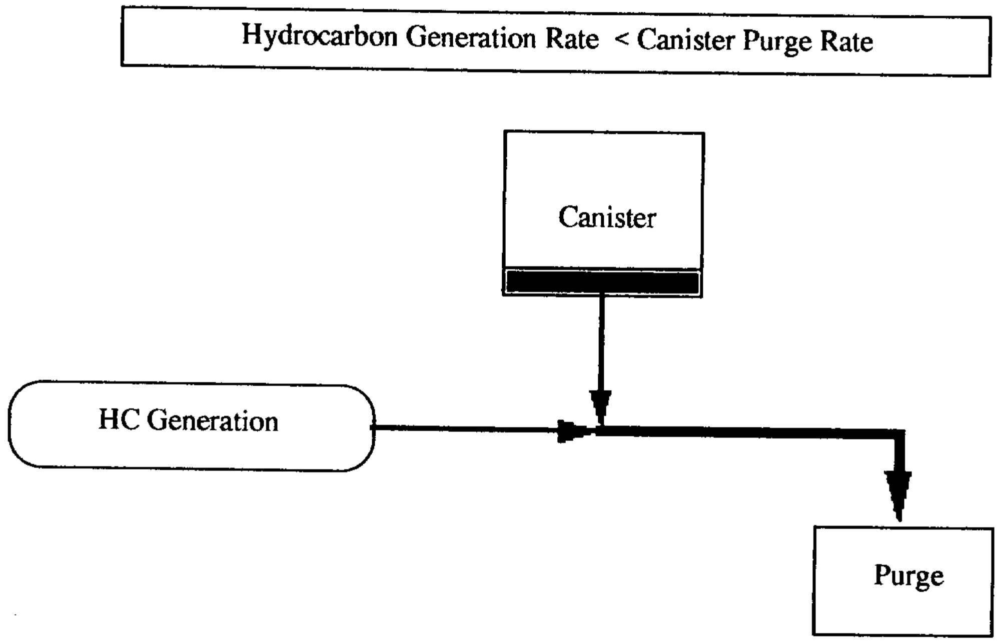
The initial canister capacity at the beginning of a driving event may be defined as the amount of additional hydrocarbon mass that the canister is capable of storing. This initial capacity is equal to the total canister capacity less the mass of hydrocarbons remaining in the canister from previous vehicle operation.

Running loss emissions are generally not linear with respect to the variables which affect the emissions. This can be understood by considering two modes of operation defined by the relative magnitude of hydrocarbon generation and canister purge rates.

In the first mode (Type I), the hydrocarbon generation rate is less than the purge rate. Figure 7 illustrates this condition. In the example, the purge rate is large enough to consume all the hydrocarbons currently being generated by the vehicle. Type I operation also includes those conditions in which HC mass remaining from past events is removed from the canister by excess purge. If the idealized vehicle continues operating under these conditions, it will never experience running losses from the canister.

Type I behavior occurs when the vehicle purge rate exceeds the HC generation rate. In a properly functioning vehicle, these conditions are normally satisfied with low fuel volatilities and/or low fuel temperatures during operation modes that do not include significant fractions of idle and low speed driving.

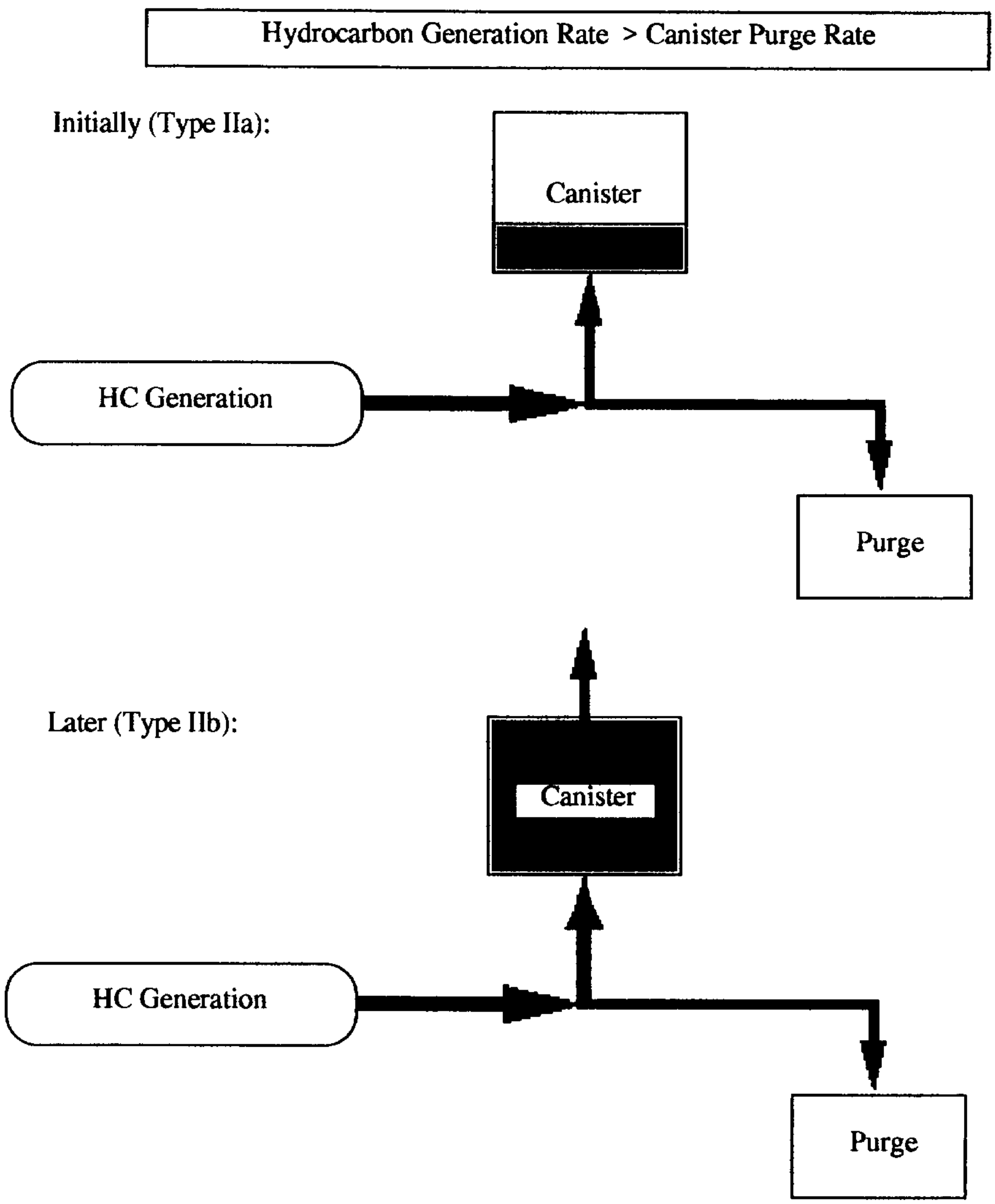
Figure 7
Evaporative Emissions Control System Operation for Type I Behavior



The second characteristic operating mode (Type II) occurs when the hydrocarbon generation rate is greater than the purge rate. This can happen when the purge rate is low or when the hydrocarbon generation rate is high. This behavior is displayed in Figure 8. At the start of a given period of vehicle operation, initial canister capacity is used to store HC vapors which are generated but not purged by the engine. This will be referred to as Type IIa behavior. When the available canister capacity has been used, the excess hydrocarbons become running loss emissions. This will be called Type IIb behavior.

During Type II operation, running loss emissions will always eventually occur if the vehicle is driven long enough at the same operating conditions.

Figure 8
Evaporative Emissions Control System Operation for Type II Behavior



When the idealized vehicle is operated at constant speed and dynamic thermal equilibrium, constant running loss emission rates will be observed. This Type II behavior is shown graphically in Figure 9 as cumulative running loss emissions versus time. Running loss emissions are zero until time τ, when they begin to increase at a slope equal to Δ(RL)/Δt. τ will get shorter and the rate of running loss emissions will increase as RVP and temperature conditions become more severe. This trend is shown in Figure 10.

Figure 9
Ideal Evaporative Control System Type II Behavior

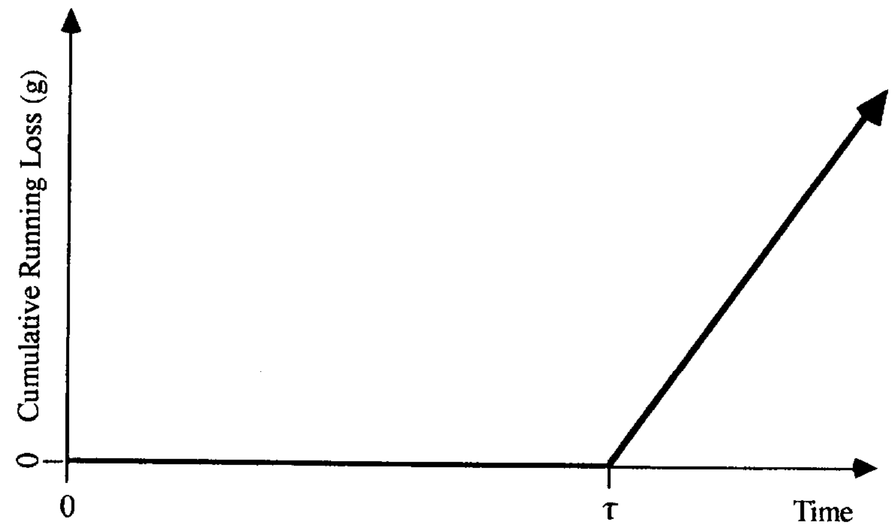
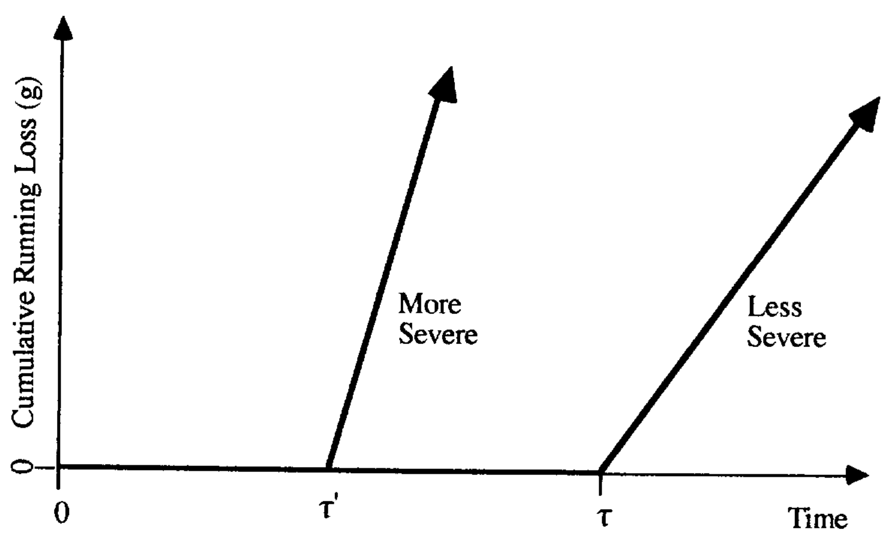


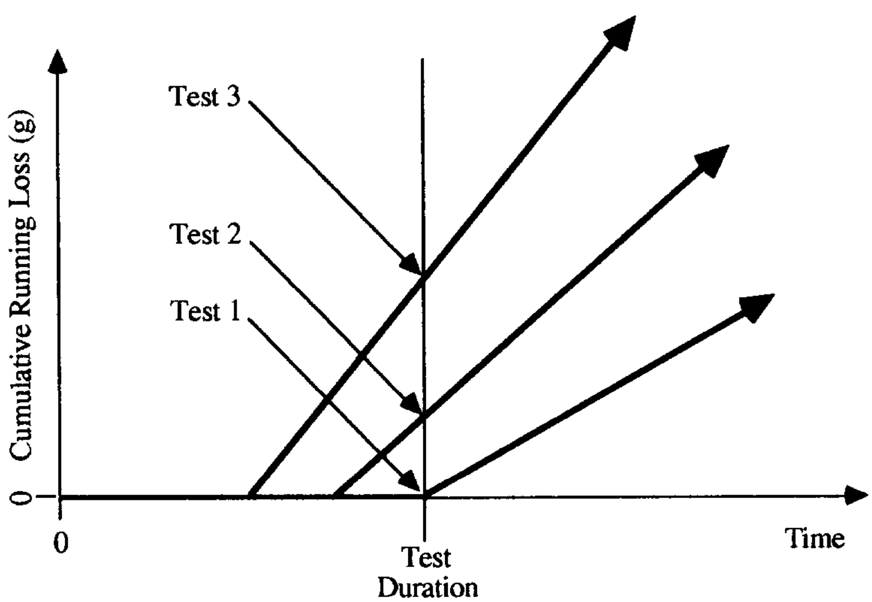
Figure 10
Ideal Evaporative Control System Type II Behavior
Affect of Environmental Severity



Changes in canister purge rate under constant severity conditions produce a parallel effect on running loss emissions from the evaporative canister. Lower purge rates result in both a shorter period before the onset of running loss emissions and an increased rate of emissions following canister saturation.

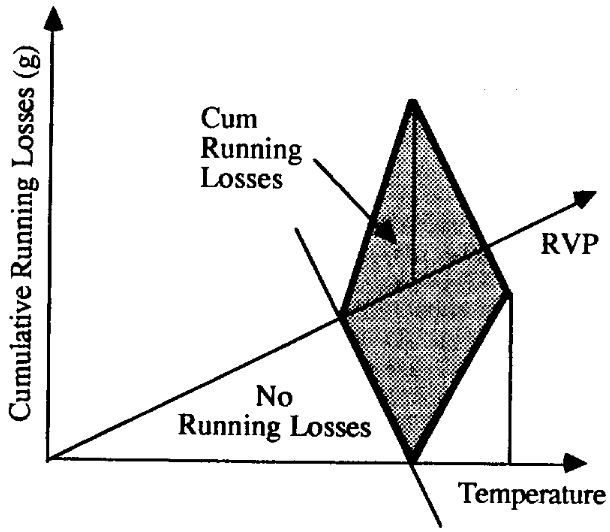
If a simplified steady state model is used to predict running loss emissions under a variety of environmental conditions (or test severities), the results displayed in Figure 11 may result. This figure parallels the results frequently observed when testing a single vehicle with a matrix of different driving cycles, fuel RVPs and temperatures. When test severity is equal to or less than Test 1, very low results are observed. When test conditions exceed the severity of Test 1 levels, large non-zero cumulative running losses are seen. In addition, because the emission generation slopes are increasing as the breakthrough (canister saturation) time decreases, the differences between tests are increasing. Thus, the difference between test 3 and test 2 is greater than the difference between test 2 and test 1. These factors combine to account for the significant non linearities observed during running loss testing.

Figure 11
Emission Levels after Fixed Length of Time
With a Variety of Severities



A final extension of the concepts developed with the simple steady state model is displayed in Figure 12. In this example, two dimensional families of test conditions are modeled to define a three dimensional Type II running loss emissions plane. While the example uses RVP and temperature as the driving forces, purge rate, canister capacity or other factors could be considered in a similar fashion.

Figure 12
Combined Severity Effect on Running Losses



The important feature to note in this presentation is the joint effect of the two variables. While Type II operation may never occur at a given level of temperature or RVP, it may occur rapidly under the combined influence of the the two factors. Conversely, the unitless "No Running Loss" area for a specific vehicle may include all normally encountered temperature and RVP operating conditions, resulting in a vehicle which does not produce running loss emissions under any combination included in a particular test plan.

Actual vehicles operate differently from the simplified model in several areas.

Evaporative control canisters do not actually change from 100% efficiency to 0% efficiency at a specified point. Initially, a canister will retain less than 100% of the vapors presented. A small fraction of vapors will pass through the canister regardless of the relative capacity remaining. A "saturated" canister, on the other hand, will continue to retain a small fraction of the vapors presented. The net effect on hydrocarbon control is that breakthrough is not an abrupt, but rather a smooth phenomenon.

Vehicles are not normally operated at a constant speed, as assumed in the "ideal" steady state model. Purge on/off state and purge rate actually depend on vehicle speed and engine loading. During some portions of vehicle operation the canister may be purging, while at other times HC loading may exceed purge. Excess hydrocarbons will saturate the canister and result in running loss emissions if, on average, the hydrocarbon generation rate exceeds the purge rate. Cumulative running loss emissions measured during a particular test are the result of the net effect of all operating conditions experienced during the cycle.

It has been found that even on vehicles where the canister is being heavily purged (Type I), the vehicle still has emissions while it is being driven. These emissions, which may be referred to as "fugitive" emissions, are present under all test conditions. The dependence of fugitive emissions on temperature, RVP, driving pattern, and vehicle type is probably different from running loss emissions resulting from canister saturation. It is important to separate emissions data into fugitive-dominated and running loss-dominated categories, so that the separate mechanisms and the total emissions can be modeled more accurately.

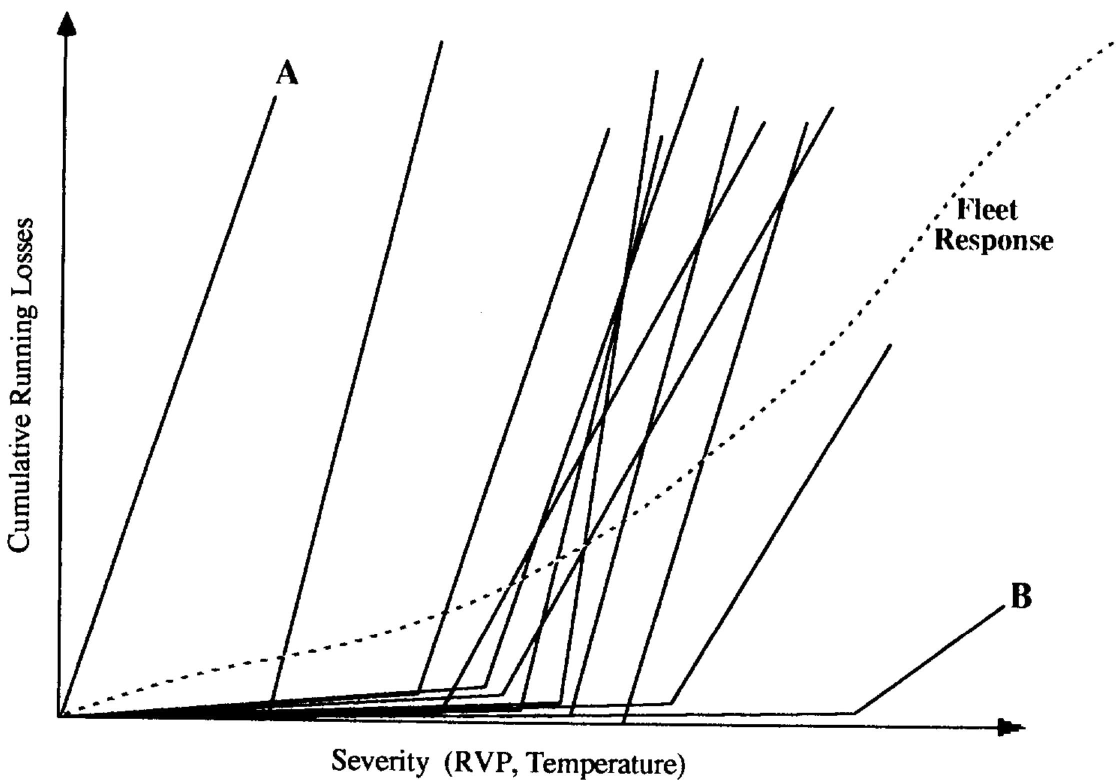
The initial canister capacity of a vehicle depends on the history of the vehicle before the running loss episode. If the vehicle experienced a large diurnal or severe hot-soak emission before the drive, the canister capacity will be small, and the onset of running loss emissions may occur soon after the drive begins. The hydrocarbon generation rate also depends on the state of the vehicle. If the vehicle begins a driving sequence when it is cold, the hydrocarbon generation rate will be different than if the vehicle is warm from an earlier drive. As the fuel temperature increases, the hydrocarbon generation rate may be expected to increase.

Because of vehicle differences in canister capacity, purge rate, and hydrocarbon generation rate, an individual vehicle's emissions will move from fugitive-dominated to running loss-dominated emissions at different test condition severities.

The control systems of some vehicles maintain very low running losses until extreme conditions are encountered, while others experience running losses under mild conditions. As a result, the fleet will include a distribution of the critical severity conditions necessary for vehicles to move from fugitive-dominated to running loss-dominated behavior. This effect should be accounted for when modelling the vehicle population.

A hypothetical picture of the spread in responses of different vehicles to severity is shown in Figure 13. The figure shows cumulative Running Loss emissions for a one-hour trip as a function of test condition severity. Vehicle A has cumulative Running Loss emissions at the mildest conditions. This would be typical of an older model vehicle with no canister or purging of evaporative emissions. Vehicle B is a modern vehicle which controls Running Loss emissions to very low levels until conditions become very severe,

Figure 13
Combined Vehicle Effects



and only then produces Running Losses. Most of the in-use vehicle fleet experiences behavior between these two extremes. The figure has been drawn with an abrupt kink between Type I and Type II behavior for each vehicle. Real vehicles would exhibit a smoother transition. To predict the Running Loss behavior of this fleet of cars, the Running Loss emissions per vehicle are averaged, as shown by the dashed line on the plot. Because a few vehicles emit Running Loss emissions under mild conditions and a few others control emissions until the most extreme conditions occur, the curve describing the Running Loss behavior of the fleet is not nearly as abrupt as those for individual vehicles.

It is, therefore, important to average the Running Loss behavior of a representative fleet of vehicles to ensure that the response of the vehicle population to severity is accurate. If only high-emitting vehicles are included, emission predictions will not be accurate in magnitude or in response to changes in severity.

B. Analysis of EPA Data Set

The high cost and non-linearity of Running Loss testing has resulted in test plans which substantially depart from the randomization requirements of traditional statistical analysis. The two largest Running Loss programs to date, the ongoing EPA program and the ARB program which is the subject of this report, each used initial test results to determine if subsequent tests were to be performed with a specific vehicle. These two data sets investigate the effects of different levels of variables on Running Losses. In both programs, additional testing was normally performed only on relatively high-emitting vehicles. For both programs, this has resulted in data sets which are unbalanced in the variables of interest to Running Losses.

In this section of the report, examples from the EPA database will be used to demonstrate fundamental vehicle behavior patterns with respect to Running Losses. Initially, this will be accomplished by examining the trends in selected vehicles. Based on these relationships, the entire sample vehicle population will be modeled.

It is important to note at this point that the primary purpose of this program was to provide Running Loss Emission data to the test sponsor. All final Running Loss emission factors will be computed by members of the Air Resource Board staff. A sub-task of the program was, based on the combined experience of ATL and Radian, to suggest approaches to reduce the raw results to final numbers. In this section of the report, a variety of techniques and approaches will be demonstrated using examples from the EPA and ARB data sets. The models derived in this report are for demonstration purposes only. The results of the demonstration models are very preliminary and should not be viewed as complete generalized descriptions of vehicle behavior.

ATL has been performing Running Loss Emission tests for inclusion in the EPA Emissions Factors data base since 1988. More than 100 different vehicles have been completed to date. The primary difference between EPA's efforts and ARB's needs has been the areas of vehicle age (California's current vehicle population vs EPA's need for 1995 and later models), geographical differences (higher temperatures) and regulatory differences (lower RVP fuels in California). A number of important trends can be drawn from the EPA experience, however.

Examining the EPA data demonstrates the important trends seen in Running Loss data and demonstrates how these trends may be modeled.

In this section, Running Loss data from the EPA data set will be used to:

- Examine trends in individual vehicles.

- Model individual vehicle Running Loss behavior for a subset of the data.

- Extend these relationships to model the vehicle population.

Sample data from four vehicles tested in the EPA ongoing test program are presented in Table 8. This table displays the hydrocarbon mass emitted from the test vehicles for each bag in a test sequence. The tests were performed at different test fuel RVPs and nominal ambient temperatures. The grams of hydrocarbon emitted for sequential bags in a test sequence can be added to produce the cumulative mass emitted at any point in the test sequence. Thus, a calculation of the cumulative grams emitted for each bag in the sequence shows how the total hydrocarbon emissions for each vehicle are proceeding with time. Figures 14, 15 and 16 diagram the cumulative Running Loss emissions for three vehicles in Table 8. At each RVP/temperature condition, the total hydrocarbons emitted increases from bag to bag.

Figures 14, 15, and 16 are two dimensional representations of four dimensional test results. The time duration of each test is marked in "bags". The cumulative results of the test at the end of a bag are a snapshot of cumulative running losses up to the time of that bag. In addition to the factors of running losses and time, the figures add the relationship of fuel RVP and ambient temperature.

For example, Figure 14 displays the results of seven tests performed on vehicle 281 using the NYCC driving cycle. Six groups of readings are displayed in the figure - Bag 1 through Bag 6. Within each bag, the results of each temperature/RVP combination are presented.

This presentation is useful to assist in the visualization of the transition from Type I to Type II vehicle operation with actual vehicle data. A diagonal line represents the estimated point of transition within all tests in each bag. In Bag 2 of the example figure 14, the test results of 2.1 and 1.8 grams are believed to result primarily from Type I operation. The markedly higher results of 5.2, 4.5 and 9.0 grams are believed to include the transition from Type I to Type II operation. The results of 23.0 and 32.0 grams are clearly dominated by Type II evaporative emissions.

Table 8

Selected EPA Test Vehicle Running Loss Data (g/bag)
RVP, Temperature, Driving Cycle and Time Effects

Veh		Fuel		Bag Emissions (grams)					
No	Cycle	RVP	Temp	1	2	3	4	5	6
281	NYCC	11.7	95	13.3	19.2	30.2	34.6	53.7	65.5
		11.7	80	2.7	6.3	9.6	7.7	7.1	11.3
	NYCC	9.0	105	13.4	9.7	11.2	15.2	19.6	23.0
		9.0	95	2.1	2.4	3.3	4.7	6.6	6.2
		9.0	80	0.7	1.1	1.3	1.1	1.7	1.9
	NYCC	7.0	105	2.9	2.3	2.9	3.5	4.2	4.7
		7.0	95	1.1	1.0	1.2	1.9	3.4	1.7
273[a]	NYCC	11.7	95	12.3	45.4	94.6	210.0	301.5	304.5
	NYCC	9.0	105	10.3	31.5	51.8	71.6	73.3	84.1
		9.0	80	1.1	7.3	13.0	12.5	12.6	13.9
	NYCC	7.0	105	6.8	15.2	24.0	31.6	40.3	41.0

[a] Vent Line from tank to canister disconnected

271	NYCC	11.7	95	1.1	1.8	1.4	1.1	0.9	0.7
		11.7	80	0.3	0.3	0.2	0.2	0.2	0.2
	NYCC	9.0	105	0.3	0.3	0.3	0.3	0.3	0.3
		9.0	95	0.5	0.5	0.5	0.5	0.5	0.5
		9.0	80	0.2	0.1	0.1	0.1	0.1	0.1
	NYCC	7.0	105	0.2	0.2	0.2	0.2	0.3	0.3
		7.0	95	0.2	0.2	0.2	0.2	0.2	0.2
263	LA-4	11.7	95	0.1	0.2	9.2	23.4	20.4	27.7
		9.0	95	0.1	0.2	0.1	0.2	0.1	0.2
	HFET	11.7	95	0.2	0.1	0.1	0.1	0.2	.
		9.0	95	0.1	0.2	0.2	0.1	0.1	.
	NYCC	11.7	95	0.3	0.2	5.7	46.6	22.0	4.6
		9.0	95	0.2	0.2	0.1	0.1	0.1	0.2

Figure 14
Cumulative Running Losses (g) by Bag
EPA Vehicle 281 - NYCC

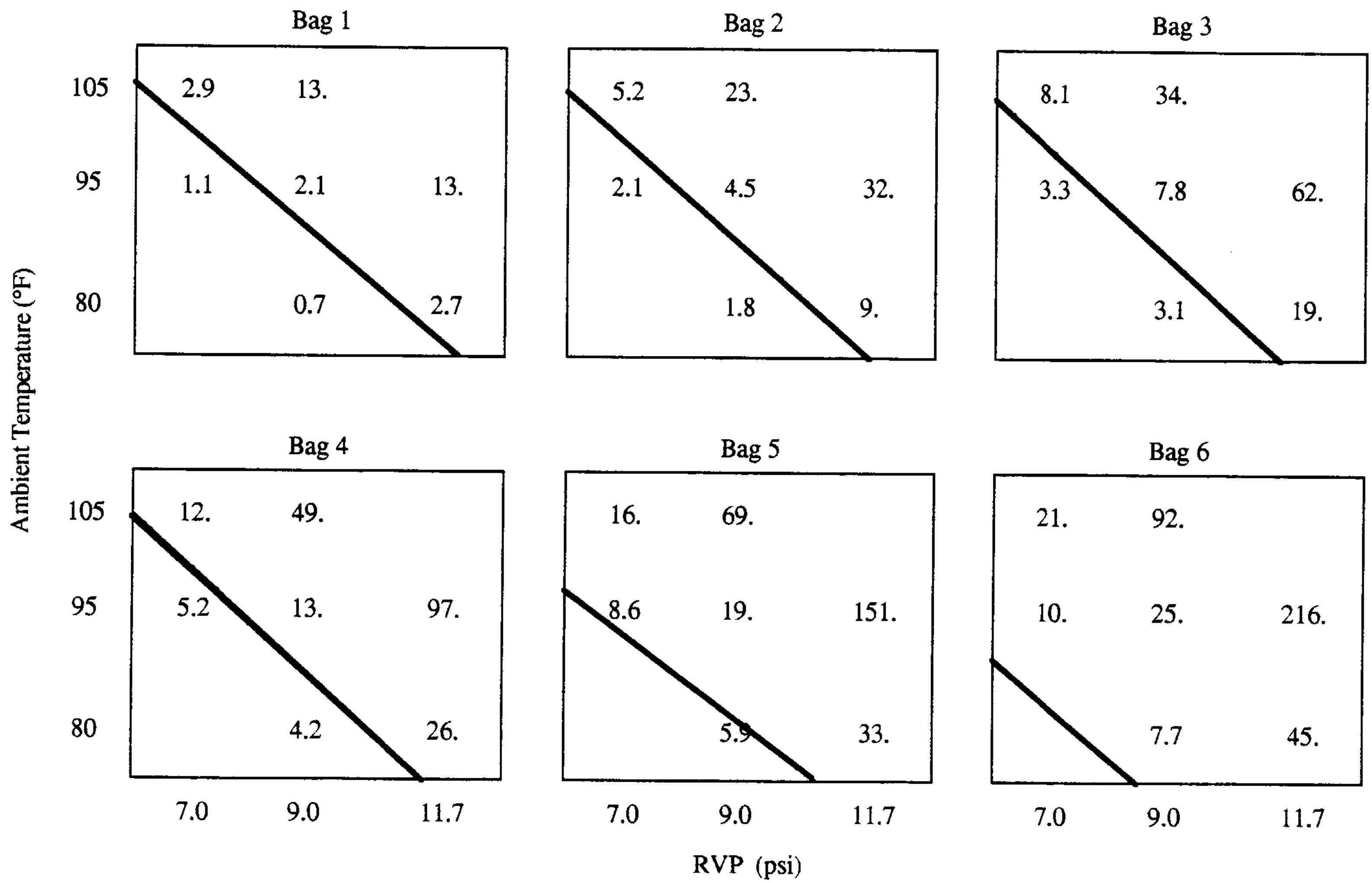


Figure 15
Cumulative Running Losses (g) by Bag
EPA Vehicle 273 - NYCC
Tank Vent Line Disconnected.

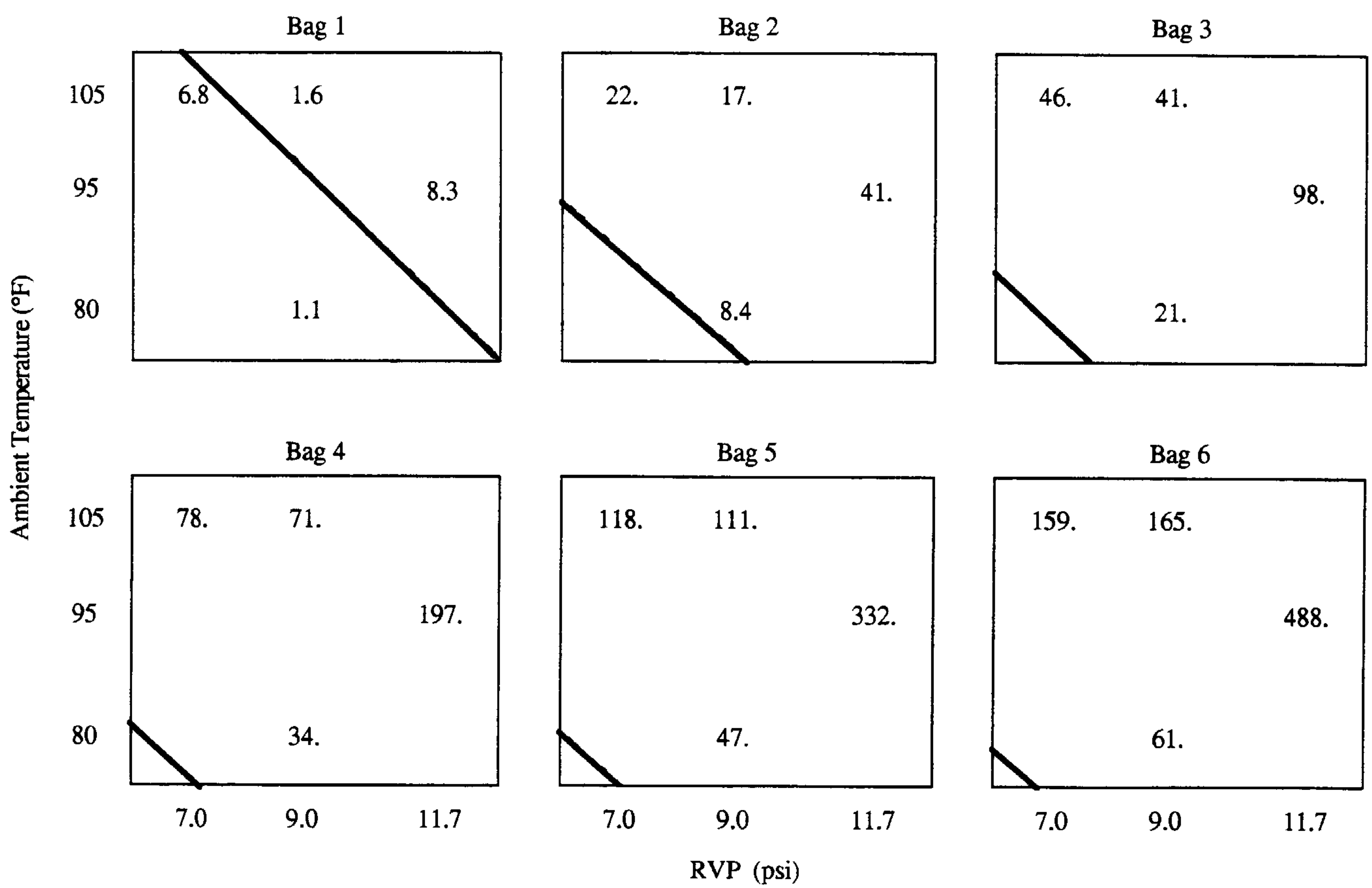
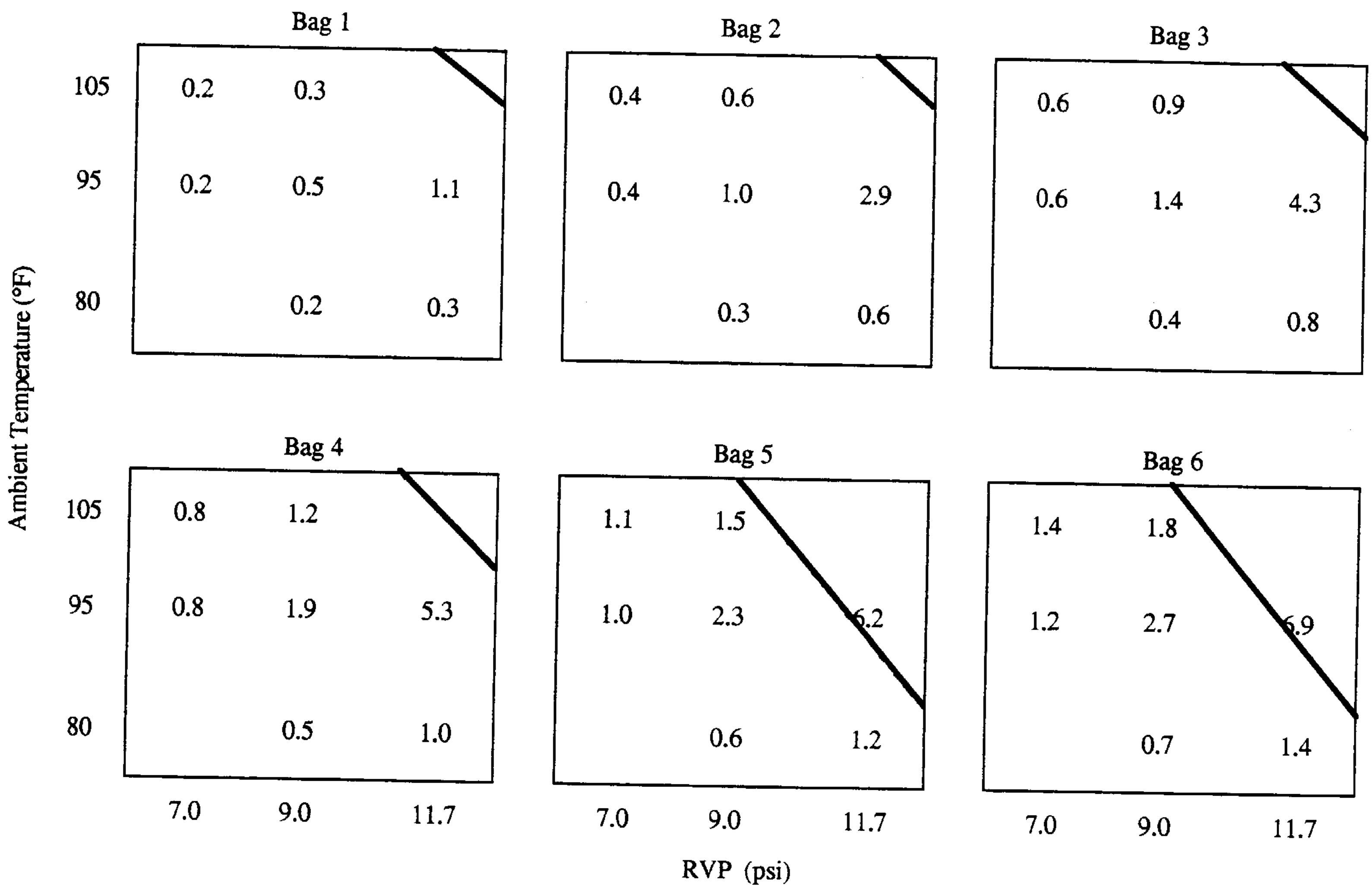


Figure 16
Cumulative Running Losses (g) by Bag
EPA Vehicle 271 - NYCC.



Examination of Table 8 and accompanying figures, as well as laboratory experience in performing tests, shows that two usually distinct patterns of behavior are present in Running Loss emissions from a properly functioning vehicle with a sealed evaporative emissions control system:

1. A relatively low, somewhat constant level of hydrocarbon emissions at the beginning of the test sequence. This mode of operation is attributed to either Type I behavior, where the canister purge is greater than the hydrocarbon generation rate, or Type IIa behavior, where excess hydrocarbons are mostly controlled by the charcoal canister prior to saturation. The measured Running Loss emissions can be considered *fugitive* emissions.

2. A high rate of hydrocarbon generation, primarily from the canister vent, in which most hydrocarbons generated in the fuel tank are passed directly through the saturated charcoal canister to the atmosphere. These are referred to as Type IIb behavior. Measured Running Loss Emissions are the sum of the fugitive emissions and the Type IIb Running Loss emissions.

During a single test sequence, a given vehicle may display either or both of these mechanisms. The combination of Running Loss patterns displayed by an individual vehicle depends on the design of the vehicle's emission control system, the condition of the control system, the severity of the test condition, and the time during which the vehicle is exposed to these conditions.

If an individual vehicle starts a Running Loss in Type I and ends the emission episode in Type IIb, the vehicle obviously passes through a transition period. This period is characterized by rapidly increasing emissions attributed to the loss of canister efficiency as the nominal capacity of the canister is approached. This phenomenon occurs only when the average rate of vapor generation in the vehicle fuel tank has exceeded the average rate of canister purge.

All vehicles are assumed to have been certified using conventional evaporative test procedures. Passing the standard tests, however, does not necessarily reveal if or when canister saturation will occur during a Running Loss test. Adjustment of test parameters will have a substantial impact on the time at which the transition from controlled to uncontrolled operation occurs.

In older vehicles with no evaporative emission control system, Type I will never occur, and the vehicle will always have a Running Loss behavior similar to Type IIb. A vehicle with a malfunctioning evaporative emissions control system may behave as a vehicle with no system, or it may have some attributes of a vehicle with an evaporative emissions control system with reduced capacity. In this instance, the behavior will depend on which part of the evaporative emissions control system is malfunctioning.

For a normal vehicle with a properly operating evaporative emissions control system, Type I behavior will occur during tests which are done at less severe conditions. For more severe conditions, when the canister purge rate is less than the hydrocarbon generation rate, Running Loss behavior will move to Type II behavior.

Vehicle 281 from the early EPA testing program demonstrates some of these concepts. A number of tests were performed on that vehicle, including tests at three RVP levels and three temperatures. Table 8 summarizes the results of those tests, which were preceded by an LA-4 and followed by an overnight soak. Significant Running Losses were not detected at the conditions of 7.0 RVP/95°F and 9.0 RVP/80°F. At more severe test conditions, a low level of hydrocarbon emissions resulted until the transition to a higher emission rate occurred. This transition occurred sooner at the more severe conditions.

Figure 14 displays cumulative total results of all tests on vehicle 281. The diagram for each bag has been broken into two parts by an angular break line. Examination of the data in Table 8 suggests that in the less severe corner of each of the bag diagrams, the cumulative emissions can be attributed to Type I behavior. In the more severe part of the diagrams (on the other side of the line), the cumulative hydrocarbon emissions can be attributed primarily to Type II of behavior.

Examination of the diagrams in the order of the bags shows that, as time progresses, the transition line moves to less severe conditions. The angle of the break line on the plots indicates the trade-off between ambient temperature and fuel RVP. This trade-off is related to the hydrocarbon generation characteristics of the fuel and, to a lesser extent, vehicle characteristics. The independence of the RVP/temperature trade-off can be seen by examining the slope of the break line for the three different cars in Figures 14, 15, and 16.

The mechanisms on each side of the transition line have distinctly different behavior. On the low severity side, emissions tend to be fugitives, with weak dependence on temperature, RVP, and time. Fugitive emission rates are low, typically less than 1.0 grams per bag. The emissions on the high side of the transition line are fugitives plus Running Loss emissions, characterized by strong dependence on temperature, RVP, and time. Part of the time dependence of these emissions arises from the fact that the tank temperature is increasing during the test sequence. This tank temperature increase causes an increase in hydrocarbon generation rate and results in increased Running Loss emissions.

To distinguish between early fugitive emissions and later Running Losses, the characteristics of the emission rates with respect to changes in temperature, RVP, and time should be examined. In many cases, for individual vehicles, the distinction is straightforward. However, in some cases, it is difficult to distinguish between the two, although it is important to know which mechanism is occurring during the Running Loss emissions measurement because they respond differently to temperature, RVP, time, and driving cycle. Failure to differentiate between the two types of emissions will result in a Running Loss emissions model which will smear the strong dependences of the later Running Losses with the weak dependences of the fugitive emissions. The result will be an overall fleet emission model which is not as accurate as it might otherwise be.

Vehicle Effects Observations

The example data shown in Table 8 and Figures 14-16 show the results of three vehicles with markedly different behaviors. Vehicle 281 shows a wide range of behavior from fugitive emissions to strongly increasing Running Losses. On the other hand, Vehicle 273a is a vehicle with its tank vent line to the canister disconnected, and therefore behaves like an uncontrolled vehicle. Vehicle 271 is a vehicle with very good control of all Running Loss emissions. Throughout all of the test sequences, even at the most extreme conditions, this vehicle's emission results do not indicate any evaporative emissions control system breakthrough to create Running Losses other than fugitive emissions.

These three vehicle examples illustrate that a wide range of behavior is possible in the vehicle fleet. Under the same conditions, vehicles can range from almost completely controlled at the most extreme conditions to no control at even the mildest conditions. Figures 14-16 show this by the estimated location of the break between fugitive and type IIB Running Losses. The location of this break line depends on the vehicle characteristics, including, the purge rate of the canister, the initial canister capacity, and the relative magnitudes of the fugitive emissions and canister breakthrough Running Loss emissions. The relative magnitudes of the Running Loss emissions, in turn, depend on the characteristics of the vehicle, the vehicle's driving history just before the test sequence, RVP, tank temperature, the duration of the sequence, and the type of driving which is done.

The wide range of vehicle behavior for fugitive and conventional Running Loss emissions puts two demands on the development of a model to predict total emissions. The first is that the vehicles in the test fleet must be chosen to accurately represent the distribution of vehicles in the total population. In both the EPA and the ARB studies, deliberate efforts were made to investigate the temperature, RVP, and driving cycle dependence of Running Loss emissions, predominantly on vehicles with high initial emissions. However, when emissions for the fleet as a whole are to be calculated, it is important to include all those vehicles with low Running Loss emissions at the same test conditions. The second demand is that when the individual vehicle data obtained in the test fleet are extended to predict emission for the vehicle population, appropriate modeling techniques must be used to prevent inadvertent biasing.

Temperature and RVP Effect Observations

Examination of the data in Table 8 and Figures 14-16 shows the dependence of these vehicle emissions on temperature and RVP. In general, the emissions tend to increase with increasing ambient temperature and RVP. In the data analysis and model building phases, it is important to examine the data for interactions between temperature and RVP. RVP/temperature interactions are evident in the emissions from uncontrolled vehicles and it is possible that these trends exist in the emissions of the controlled vehicles as well.

Driving Pattern Effect Observations

In the EPA Running Loss program, primarily multiple LA-4 and multiple NYCC driving cycles were used. A few Highway Fuel Economy Tests (HFETs) also were performed early in the program. An example where all three sequences were tested on a single vehicle is shown in the results for vehicle 263. Even without plotting these data, it is clear that for both the LA-4 and the NYCC sequences, the vehicle initially was in control but then broke into high Running Loss emissions. With the HFET sequences, however, the vehicle continued to stay in the controlled state, most likely due to a continuous canister purge, since the HFET includes only very limited idle and low speed operation. As a result, the overall canister purge rate was greater than the hydrocarbon generation rate. On the other hand, for the LA-4 and NYCC sequences, the average canister purge rate was less than the hydrocarbon generation rate and the canister eventually saturated and broke through to release substantial Running Loss emissions.

The connection between canister purge rate and vehicle driving cycle can be different for different vehicles in the population. In addition, instantaneous canister purge rate depends on instantaneous vehicle speed and acceleration. Since vehicle speed may be changing, the total effect of canister purge for an individual vehicle is difficult to define. As a consequence of these uncertainties, estimates of the effect of canister purge on Running Loss emissions are difficult to define and are currently beyond the reach of Running Loss emissions modeling. The most reasonable approach to evaluate the effects of driving patterns on Running Loss emissions is to analyze and model the dependence of other variables, such as temperature, RVP, and time on Running Loss emissions for each different driving cycle.

Initial Canister Capacity Effect Observations

Table 9 shows the results of Running Loss emissions tests on a vehicle which was preconditioned for each test in two different ways. In one case, the vehicle was prepared by performing an LA-4, followed by an overnight soak, while in the second the vehicle also experienced a diurnal heat build (ie - fuel heating) prior to the Running Loss test. The results on this particular vehicle show a difference in the Running Loss emissions. In the first instance, the diurnal heat build apparently caused the Running Loss emissions to break through earlier and to be higher than for the non Diurnal tests. The apparent reason for this difference in behavior is that the Diurnal Heat Build generated more hydrocarbons, reducing the charcoal canister capacity more than the overnight soak alone did.

Table 9.
Initial Canister Capacity Effects
Vehicle 251

RVP	Fuel Temp	Diur	Emissions / bag (grams) 1	2	3	4	5	6
11.7	80.0	No	0.1	0.2	0.2	0.2	1.3	54.1
		Yes	0.2	0.2	0.1	32.3	36.8	110.5
11.7	95.0	No	0.3	0.7	17.9	99.9	75.1	134.9
		Yes	2.6	36.8	41.7	134.8	85.5	180.4
10.4	80.0	No	0.2	0.2	0.2	0.2	0.2	11.5
		Yes	0.1	0.1	0.1	0.1	0.1	10.2
10.4	95.0	No	0.2	0.2	0.2	0.2	0.2	0.3
		Yes	0.4	0.1	0.1	33.5	37.2	122.0

Modeling of Individual Vehicle Trends

To create a model of Running Loss emissions for the vehicle population, all trends observed in individual vehicles must be combined. Before this is done, the trends of individual vehicles must be determined. In this section, individual vehicle trends are modeled for part of the EPA data to demonstrate how this modeling could be performed and to provide suggestions about techniques which can be used to analyze the data.

Approach of the Modeling Demonstration

In demonstrating how modeling might be performed, a subset of the large EPA database is used. The chosen subset has the following features:

- 1981+ vehicles;
- LDVs and LDT1s;
- Evaporative system passed a check;
- 3 LA-4s performed (6 bags); and
- Measurements include the 11.7 RVP/95°F condition.

The data to be analyzed represent only the cumulative Running Loss in grams from all six bags. Carbureted and fuel-injected vehicles are analyzed separately. The cumulative Running Loss emissions at Bag 6 are separated into fugitive emissions and Type IIb Running Loss emissions. Each of these types of emissions are modeled for each vehicle subject to the following assumptions:

1. Each vehicle responds in the same way to temperature and RVP.
2. Emission differences between vehicles are factors (ie - vehicle design and condition is significant).

Because of the relatively large number of vehicles and different test conditions in the EPA data subset, it is possible to use regression techniques to model individual vehicle emissions. These techniques will not work as well in the ARB data set since it is smaller. However, since the ARB and the EPA data were both collected at the same laboratory, it would make sense to combine both the EPA data and the ARB data so that the more advanced techniques could be used to produce a more accurate model of the Running Loss emissions for the fleet as a whole.

Even in the EPA data set, where large numbers of vehicles were tested, the data are unbalanced, meaning that every vehicle was not tested at every possible condition of RVP and ambient temperature. The reason for this is that once a vehicle has been tested at severe conditions and found to be not emitting significant Running Losses, testing at less severe conditions does not make sense. To compensate for the unbalanced nature of the data set, class regressions were used to estimate Running Loss emission value and uncertainty at each test condition. The two test parameters, RVP and ambient temperature, were treated as class variables with RVP having four levels and ambient temperature having three. In the class regression, a response for each combination of levels of the variables is determined.

To separate the effects of RVP and ambient temperature from the idiosyncratic effects of individual vehicles, differences between vehicles are calculated as a multiplicative offset from the average vehicle behavior. Thus, the emissions of an individual vehicle will be the average vehicle's behavior times its multiplicative offset value. To determine the best average value at each test condition, the regression equation contains all interactions of RVP and ambient temperature. Fitting the data to continuous relationships in RVP and ambient temperature can more reliably be done after the average values at each test condition are examined.

A list of the vehicles and the vehicle characteristics used for this demonstration model are given in Table 10.

Table 10
Demonstration Model Vehicle Characteristics

Veh No.	MY	Make	Model	Fuel Delivery	Cert Class	Evap Inspect
250	85	FORD	ESCO	CARB	LDV	P
251	87	PONTIAC	BONN	FI	LDV	P
252	85	FORD	ESCO	CARB	LDV	P
253	83	PLYMOUTH	TURI	CARB	LDV	P
254	85	TOYOTA	TERC	CARB	LDV	P
262	88	FORD	TEMP	FI	LDV	P
263	88	CHEVROLE	CORS	FI	LDV	P
264	88	NISSAN	SENT	FI	LDV	P
265	88	TOYOTA	CORO	CARB	LDV	P
266	88	MERCURY	COUG	FI	LDV	P
269	88	MERCURY	TRAC	FI	LDV	P
270	87	CHEVROLE	CAVA	FI	LDV	P
271	87	CADILLAC	FLEE	CARB	LDV	P
272	87	CHEVROLE	CAPR	CARB	LDV	P
273	86	CHEVROLE	ASTR	FI	LDT1	P
274	87	MERCURY	MARQ	FI	LDV	P
277	88	FORD	TEMP	FI	LDV	P
279	88	CHEVROLE	CELE	FI	LDV	P
281	88	MERCURY	COUG	FI	LDV	P
300	86	DATSUN	P-UP	FI	LDT1	P
301	78	FORD	MUST	CARB	LDV	P
302	75	CHEVROLE	MONT	CARB	LDV	P
303	76	OLDSMOBI	CUTL	CARB	LDV	P
305	73	DODGE	CHAR	CARB	LDV	P
306	80	FORD	FAIR	CARB	LDV	P
307	80	CHEVROLE	CITA	CARB	LDV	P
308	84	TOYOTA	P-UP	CARB	LDT1	P
311	87	FORD	F150	FI	LDT1	P
312	85	TOYOTA	P-UP	CARB	LDT1	P
313	83	FORD	RANG	CARB	LDT1	P
314	87	CHEVROLE	BLAZ	FI	LDT1	P
316	88	FORD	RANG	FI	LDT1	P
317	75	CHEVROLE	MALI	CARB	LDV	P
318	86	CHEVROLE	S-10	FI	LDT1	P
401	89	PONTIAC	GRAN	FI	LDV	P
402	88	CHEVROLE	BERE	FI	LDV	P
403	88	CHEVROLE	CAVA	FI	LDV	P
404	89	NISSAN	STAN	FI	LDV	P
405	89	CHRY	LEBA	FI	LDV	P
406	89	DODGE	COLT	FI	LDV	P
407	89	CHRY	NEW	FI	LDV	P

Table 10
Demonstration Model Vehicle Characteristics

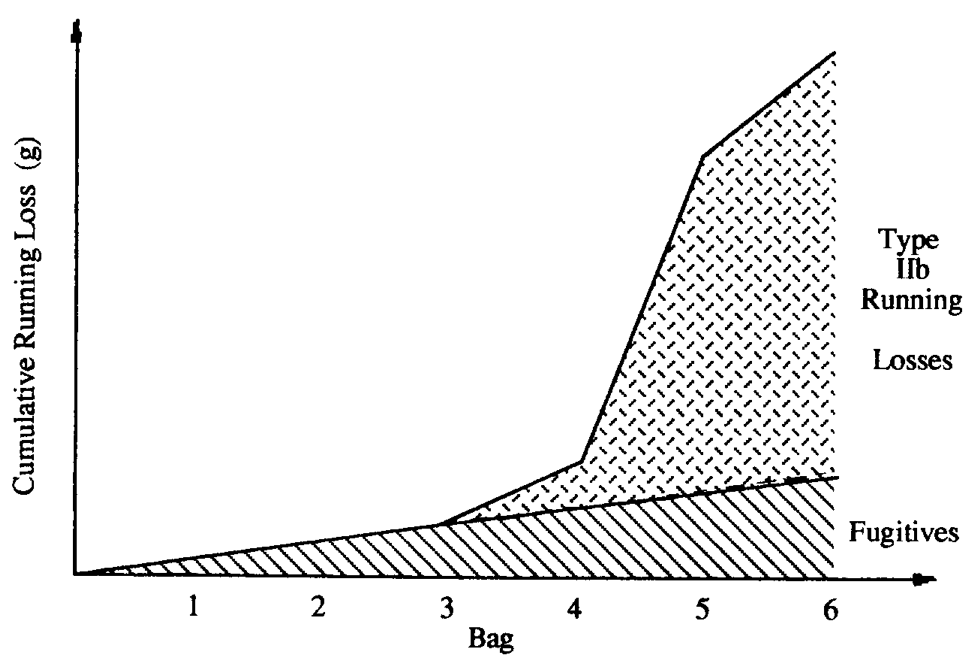
Veh No.	MY	Make	Model	Fuel Delivery	Cert Class	Evap Inspect
408	86	OLDSMOBI	DELT	FI	LDV	P
409	87	MAZDA	RX7	FI	LDV	P
410	86	CHRY	NEW	FI	LDV	P
411	88	BUICK	LESA	FI	LDV	P
412	88	PLYMOUTH	VOYA	FI	LDT1	P
413	88	MERCURY	COUG	FI	LDV	P
414	88	CHEVROLE	CORS	FI	LDV	P
415	87	DODGE	600	FI	LDV	P
416	89	FORD	THUN	FI	LDV	P
417	89	FORD	PROB	FI	LDV	P
418	89	DODGE	DYNA	FI	LDV	P
419	89	PLYMOUTH	ACCL	FI	LDV	P
420	89	CHRY	LEBA	FI	LDV	P
422	87	FORD	RANG	FI	LDT1	P
423	86	FORD	VAN	FI	LDT1	P
424	89	FORD	F150	FI	LDT1	P
425	89	CHEVROLE	C150	FI	LDT1	P
426	85	DODGE	RAM	CARB	LDT1	P
427	87	DODGE	DAKO	CARB	LDT1	P
428	86	CHEVROLE	ASTR	FI	LDT1	P
429	89	CHEVROLE	S-10	CARB	LDT1	P
430	87	DODGE	RAM	CARB	LDT1	P
431	86	CHEVROLE	C-10	CARB	LDT1	P
432	88	CHEVROLE	G-20	FI	LDT1	P

Separation of Data by Mechanism

Whenever a process is characterized by two mechanisms, modelers of the process should consider the use of separate models, one for each mechanism, to prevent the smearing of important effects. This will produce an overall model more true to the behavior of the process. An approach in the development of such models – in this case, Type I and Type II running loss emissions models – is to estimate the relative contribution of each mechanism to each individual data point.

This separation can be demonstrated by examining Figure 17. The hypothetical data shown here shows the cumulative Running Loss emissions by bag for a vehicle. Data values are connected by the solid line. In the example data shown, the measurements for Bags 1, 2, and 3 have been assigned to purely Type I emissions. Emission values for Bags 4, 5, and 6 have been assigned to the sum of Type I and Type II Running Losses. Based on experience with examining Running Loss data, Bag 4, 5, and 6 values can be separated into Type I and Type II values by assuming that the rate of Type I emissions generation is constant throughout the test sequence and can be estimated by the rate demonstrated in the early bags (Bags 1, 2, and 3). Any emissions larger than these Type I emissions are designated as Type II emissions, as shown in the figure.

Figure 17
Separation of Running Loss Components



For most vehicle emissions data, visual inspection of the bag-by-bag emissions can be used to clearly separate fugitive from Running Losses. On other vehicles, this is difficult. For the purposes of this model demonstration, we chose to use a computer technique to estimate the contributions of fugitive and Running Losses to the cumulative Running Loss emissions at Bag 6. These criteria provide a way of separating the data for the purposes of this demonstration. The criteria were:

- Any bag emission larger than 2 grams indicates the beginning of Type IIb Running Loss emissions.
- The bag whose additional hydrocarbon mass causes the cumulative hydrocarbon emissions at that point to exceed 6 grams indicates that Type IIb Running Loss emissions are beginning.
- The fugitive emissions rate throughout the test sequence is the average of the grams per bag in each bag up to the onset of Type IIb Running Loss emissions.
- The emissions of any bag after the onset of Type IIb Running Losses in excess of the average fugitive emissions are attributed to Type IIb Running Losses.
- If Type IIb Running Losses begin at Bag 1, the fugitive Running Losses cannot be estimated, but they must be less per bag than the magnitude of the grams hydrocarbon in the first bag.
- If, by the above criteria, Type IIb Running Loss emissions do not begin by Bag 6, the Type IIb Running Loss emissions for this test sequence are zero.

The above criteria were arrived at by an examination of the data in this subset and were found to create a reasonable first approximation of the separation of the data into fugitive and Running Loss emissions. A list of all the separations in the data subset are given in Table 11. This initial approach does not consider the weak response of fugitive Running Losses to temperature and RVP.

Table 11
Separation of Running Loss Emission Components

Veh No	Fuel Metering	Fuel RVP	Temp (°F)	Total RL	Fugitive (grams)	Type IIb (grams)
250	CARB	11.7	80	100.21	4.56	95.65
250	CARB	10.4	80	55.65	2.28	53.37
250	CARB	9.0	80	11.14	6.92	4.22
250	CARB	11.7	95	256.48	.	256.47
250	CARB	10.4	95	180.38	5.70	174.68
250	CARB	9.0	95	29.99	7.76	22.23
251	FI	11.7	80	56.07	2.34	53.73
251	FI	10.4	80	12.55	1.24	11.31
251	FI	9.0	80	0.92	0.92	.
251	FI	11.7	95	328.84	3.09	325.75
251	FI	10.4	95	1.30	1.30	.
251	FI	9.0	95	0.96	0.96	.
252	CARB	11.7	80	5.16	5.16	.
252	CARB	11.7	95	95.13	4.95	90.18
253	CARB	11.7	80	52.72	.	52.71
253	CARB	11.7	95	263.87	.	263.86
254	CARB	11.7	80	1.81	1.81	.
254	CARB	11.7	95	2.60	2.60	.
262	FI	11.7	95	72.47	1.11	71.36
262	FI	9.0	95	0.83	0.83	.
262	FI	11.7	95	68.52	4.14	64.38
262	FI	7.0	95	0.69	0.69	.
263	FI	11.7	95	80.96	0.90	80.06
263	FI	9.0	95	0.83	0.83	.
263	FI	7.0	95	0.53	0.53	.
264	FI	11.7	95	38.14	0.48	37.66
264	FI	9.0	95	1.20	1.20	.
264	FI	7.0	95	1.29	1.29	.
265	CARB	11.7	95	2.50	2.50	.
265	CARB	9.0	95	0.56	0.56	.
265	CARB	7.0	95	0.76	0.76	.
266	FI	11.7	95	318.83	.	318.82
266	FI	9.0	95	14.79	.	14.78
269	FI	11.7	95	5.72	5.72	.
269	FI	9.0	95	0.59	0.59	.
270	FI	11.7	95	30.26	8.06	22.20
270	FI	9.0	95	2.70	2.70	.
271	CARB	9.0	105	3.14	3.14	.
271	CARB	7.0	105	1.82	1.82	.
271	CARB	11.7	80	2.58	2.58	.
271	CARB	9.0	80	2.93	2.93	.
271	CARB	11.7	95	2.56	2.56	.
271	CARB	9.0	95	1.50	1.50	.
271	CARB	7.0	95	1.23	1.23	.

Table 11
Separation of Running Loss Emission Components

Veh No	Fuel Metering	Fuel RVP	Temp (°F)	Total RL	Fugitive (grams)	Type IIb (grams)
272	CARB	9.0	105	44.01	.	44.00
272	CARB	7.0	105	18.49	8.30	10.19
272	CARB	11.7	80	3.89	3.89	.
272	CARB	9.0	80	5.48	5.48	.
272	CARB	11.7	95	41.32	1.46	39.86
272	CARB	9.0	95	2.97	2.97	.
272	CARB	7.0	95	4.79	4.79	.
273	FI	9.0	105	1.26	1.26	.
273	FI	11.7	80	0.81	0.81	.
273	FI	11.7	95	124.75	1.77	122.98
273	FI	9.0	95	0.96	0.96	.
274	FI	9.0	105	91.66	.	91.65
274	FI	11.7	80	3.75	2.19	1.56
274	FI	9.0	80	0.52	0.52	.
274	FI	11.7	95	388.73	2.82	385.91
274	FI	9.0	95	1.48	1.48	.
277	FI	9.0	105	1.47	1.47	.
277	FI	7.0	105	1.14	1.14	.
277	FI	11.7	80	0.78	0.78	.
277	FI	9.0	80	0.25	0.25	.
277	FI	11.7	95	22.95	4.14	18.81
277	FI	9.0	95	3.73	3.73	.
279	FI	9.0	105	21.45	3.72	17.73
279	FI	7.0	105	32.20	8.64	23.56
279	FI	11.7	80	47.26	9.72	37.54
279	FI	9.0	80	30.61	7.86	22.75
279	FI	11.7	95	63.61	.	63.60
279	FI	9.0	95	18.66	2.04	16.62
279	FI	7.0	95	25.99	9.96	16.03
281	FI	9.0	105	130.90	.	130.89
281	FI	7.0	105	37.10	.	37.09
281	FI	11.7	80	32.05	5.34	26.71
281	FI	9.0	80	2.68	2.68	.
281	FI	11.7	95	237.80	.	237.79
281	FI	9.0	95	33.20	.	33.19
281	FI	7.0	95	1.20	1.20	.
300	FI	11.7	95	0.87	0.87	.
300	FI	9.0	95	1.20	1.20	.
308	CARB	11.7	95	1.63	1.63	.
308	CARB	9.0	95	1.68	1.68	.
311	FI	11.7	95	0.72	0.72	.
311	FI	9.0	95	1.15	1.15	.
312	CARB	11.7	95	2.00	2.00	.
312	CARB	9.0	95	1.71	1.71	.

Table 11
Separation of Running Loss Emission Components

Veh No	Fuel Metering	Fuel RVP	Temp (°F)	Total RL	Fugitive (grams)	Type IIb (grams)
313	CARB	11.7	95	2.52	2.52	.
313	CARB	9.0	95	1.76	1.76	.
314	FI	11.7	95	39.07	2.36	36.71
314	FI	9.0	95	1.14	1.14	.
316	FI	11.7	95	1.15	1.15	.
316	FI	9.0	95	1.05	1.05	.
318	FI	11.7	95	1.23	1.23	.
318	FI	9.0	95	1.22	1.22	.
401	FI	9.0	105	14.98	1.62	13.36
401	FI	7.0	105	1.24	1.24	.
401	FI	11.7	80	15.25	3.78	11.47
401	FI	9.0	80	0.94	0.94	.
401	FI	11.7	95	398.10	2.10	396.00
401	FI	9.0	95	16.24	2.34	13.90
402	FI	9.0	105	11.99	3.24	8.75
402	FI	7.0	105	5.80	5.80	.
402	FI	11.7	80	5.80	1.92	3.88
402	FI	9.0	80	2.13	2.13	.
402	FI	11.7	95	65.99	1.44	64.55
402	FI	9.0	95	6.31	6.31	.
402	FI	7.0	95	2.69	2.69	.
403	FI	9.0	105	1.76	1.76	.
403	FI	11.7	80	0.64	0.64	.
403	FI	11.7	95	159.38	2.88	156.50
404	FI	9.0	105	1.19	1.19	.
404	FI	11.7	80	0.98	0.98	.
404	FI	11.7	95	44.10	1.00	43.10
404	FI	9.0	95	0.94	0.94	.
405	FI	11.7	95	100.78	0.78	100.00
405	FI	9.0	105	0.77	0.77	.
405	FI	9.0	105	0.81	0.81	.
405	FI	11.7	80	0.38	0.38	.
405	FI	11.7	95	230.58	3.18	227.40
406	FI	11.7	95	34.70	1.80	32.90
406	FI	9.0	105	0.95	0.95	.
406	FI	9.0	105	1.28	1.28	.
406	FI	11.7	80	0.70	0.70	.
406	FI	11.7	95	90.52	2.22	88.30
407	FI	11.7	95	297.17	4.65	292.52
407	FI	9.0	105	5.38	3.27	2.11
407	FI	9.0	105	6.41	2.12	4.29
407	FI	11.7	80	0.92	0.92	.
407	FI	11.7	95	514.12	9.42	504.70
408	FI	9.0	105	34.24	.	34.23

Table 11
Separation of Running Loss Emission Components

Veh No	Fuel Metering	Fuel RVP	Temp (°F)	Total RL	Fugitive (grams)	Type IIb (grams)
408	FI	7.0	105	16.23	6.24	9.99
408	FI	11.7	80	21.80	5.70	16.10
408	FI	9.0	80	4.40	4.40	.
408	FI	11.7	95	220.56	.	220.55
408	FI	9.0	95	27.41	9.36	18.05
408	FI	7.0	95	6.38	6.24	.
409	FI	9.0	105	213.29	0.72	212.57
409	FI	7.0	105	48.82	1.00	47.82
409	FI	11.7	80	26.71	1.02	25.69
409	FI	9.0	80	0.96	0.96	.
409	FI	11.7	95	730.48	0.60	729.88
409	FI	9.0	95	6.72	1.57	5.15
409	FI	7.0	95	0.94	0.94	.
410	FI	9.0	105	1.46	1.46	.
410	FI	11.7	80	0.91	0.91	.
410	FI	11.7	95	171.89	0.26	171.63
411	FI	11.7	95	1.06	1.06	.
411	FI	9.0	105	1.73	1.73	.
411	FI	9.0	105	0.20	0.20	.
411	FI	11.7	80	0.82	0.82	.
411	FI	11.7	95	1.50	1.50	.
412	FI	9.0	105	1.60	1.60	.
412	FI	11.7	80	0.92	0.92	.
412	FI	11.7	95	100.24	.	100.23
412	FI	9.0	95	0.94	0.94	.
413	FI	9.0	105	81.69	.	81.68
413	FI	7.0	105	2.13	2.13	.
413	FI	11.7	80	0.80	0.80	.
413	FI	9.0	80	0.51	0.51	.
413	FI	11.7	95	176.14	.	176.13
413	FI	9.0	95	4.60	2.15	2.45
414	FI	9.0	105	1.37	1.37	.
414	FI	11.7	80	1.04	1.04	.
414	FI	11.7	95	255.12	2.28	252.84
415	FI	9.0	105	0.92	0.92	.
415	FI	11.7	80	1.02	1.02	.
415	FI	11.7	95	3.25	.	3.24
416	FI	9.0	105	59.88	4.47	55.41
416	FI	7.0	105	3.81	3.81	.
416	FI	11.7	80	14.49	1.62	12.87
416	FI	9.0	80	2.16	2.16	.
416	FI	11.7	95	231.89	.	231.88
416	FI	9.0	95	3.84	3.84	.
416	FI	7.0	95	3.20	3.20	.

Table 11
Separation of Running Loss Emission Components

Veh No	Fuel Metering	Fuel RVP	Temp (°F)	Total RL	Fugitive (grams)	Type IIb (grams)
417	FI	9.0	105	43.34	0.78	42.56
417	FI	11.7	80	53.02	0.78	52.24
417	FI	11.7	95	135.06	0.96	134.10
417	FI	9.0	95	0.54	0.54	.
418	FI	9.0	105	1.16	1.16	.
418	FI	11.7	80	0.82	0.82	.
418	FI	11.7	95	594.94	5.28	589.66
419	FI	9.0	105	149.82	.	149.81
419	FI	7.0	105	40.11	7.14	32.97
419	FI	11.7	80	119.54	.	119.53
419	FI	9.0	80	29.85	9.78	20.07
419	FI	11.7	95	455.67	.	455.66
419	FI	9.0	95	83.44	.	83.43
419	FI	7.0	95	28.15	6.30	21.85
420	FI	9.0	105	1.54	1.54	.
420	FI	11.7	80	1.20	1.20	.
420	FI	11.7	95	93.83	0.92	92.91
422	FI	11.7	95	1.76	1.76	.
423	FI	11.7	95	0.73	0.73	.
424	FI	11.7	80	0.85	0.85	.
424	FI	11.7	95	1.08	1.08	.
425	FI	11.7	95	1.21	1.21	.
426	CARB	11.7	95	2.02	2.02	.
427	CARB	9.0	105	5.05	.	5.04
427	CARB	11.7	80	4.87	.	4.86
427	CARB	11.7	95	7.29	.	7.28
427	CARB	9.0	95	3.96	3.96	.
428	FI	11.7	95	1.31	1.31	.
429	CARB	11.7	95	0.80	0.80	.
430	CARB	9.0	105	2.15	2.15	.
430	CARB	11.7	80	1.46	1.46	.
430	CARB	11.7	95	2.47	2.47	.
431	CARB	9.0	105	64.06	2.94	61.12
431	CARB	7.0	105	9.91	4.96	4.95
431	CARB	11.7	80	8.12	2.58	5.54
431	CARB	9.0	80	2.50	2.50	.
431	CARB	11.7	95	224.56	7.08	217.48
431	CARB	9.0	95	7.09	2.66	4.43
431	CARB	7.0	95	1.86	1.86	.
432	FI	11.7	80	0.67	0.67	.
432	FI	11.7	95	0.91	0.91	.

Modeling of Running Loss Data

The data listed in Table 11 can be categorized to determine the range of RVP and temperature combinations present in this data subset. Table 12 shows the number of Running Loss observations used in this model demonstration separated into carbureted and fuel-injected observations. Each observation represents the result of one test sequence on an individual vehicle. It is clear from Table 12 that the data will make the best estimates for the following conditions of RVP and temperature: 9.0/95, 9.0/105, 11.7/80, and 11.7/95. Estimates at 7.0/105 may also be somewhat reasonable. At the other RVP/temperature conditions, the number of observations are so few that estimates of the effects of RVP and temperature at those conditions will not be very reliable.

The Type IIb Running Loss values listed in Table 11 were regressed against vehicle and combinations of RVP and temperature using the following relationship:

$$\ln(\text{Type IIb Running Loss}) = (\text{Vehicle}) + (\text{RVP X Temperature})$$

Since all of the vehicles had been tested at 11.7 RVP and 95°F, the results at this condition provide a means for relating the emissions of the different vehicles to each other.

Table 12
Demonstration Model Frequencies
Type IIb Running Loss Emissions

Carbureted Vehicle Test Counts

	Temperature (°F)		
RVP	80	95	105
7.0	0	2	3
9.0	2	8	5
10.4	1	1	0
11.7	7	15	0

Fuel Injected Vehicle Test Counts

	Temperature (°F)		
RVP	80	95	105
7.0	0	2	5
9.0	2	13	16
10.4	1	0	0
11.7	15	48	0

The results of the regression can be shown by considering the emission factors relative to a common RVP and temperature condition, and a list of the fitted emissions of each vehicle at that same condition. The emission factors relative to the condition 9.0 RVP and 95°F for this subset of vehicles and for the total Running Loss emissions are given in Table 13. These emission factors show an expected increase in relative emissions with increasing temperature and RVP. A statistical error is associated with each of these emission factor estimates. The errors are related to the number of observations at each test condition and will be presented when the fleet average values at the test conditions are presented.

Table 13
Type IIb Running Loss Emission Factors

Carbureted Vehicles

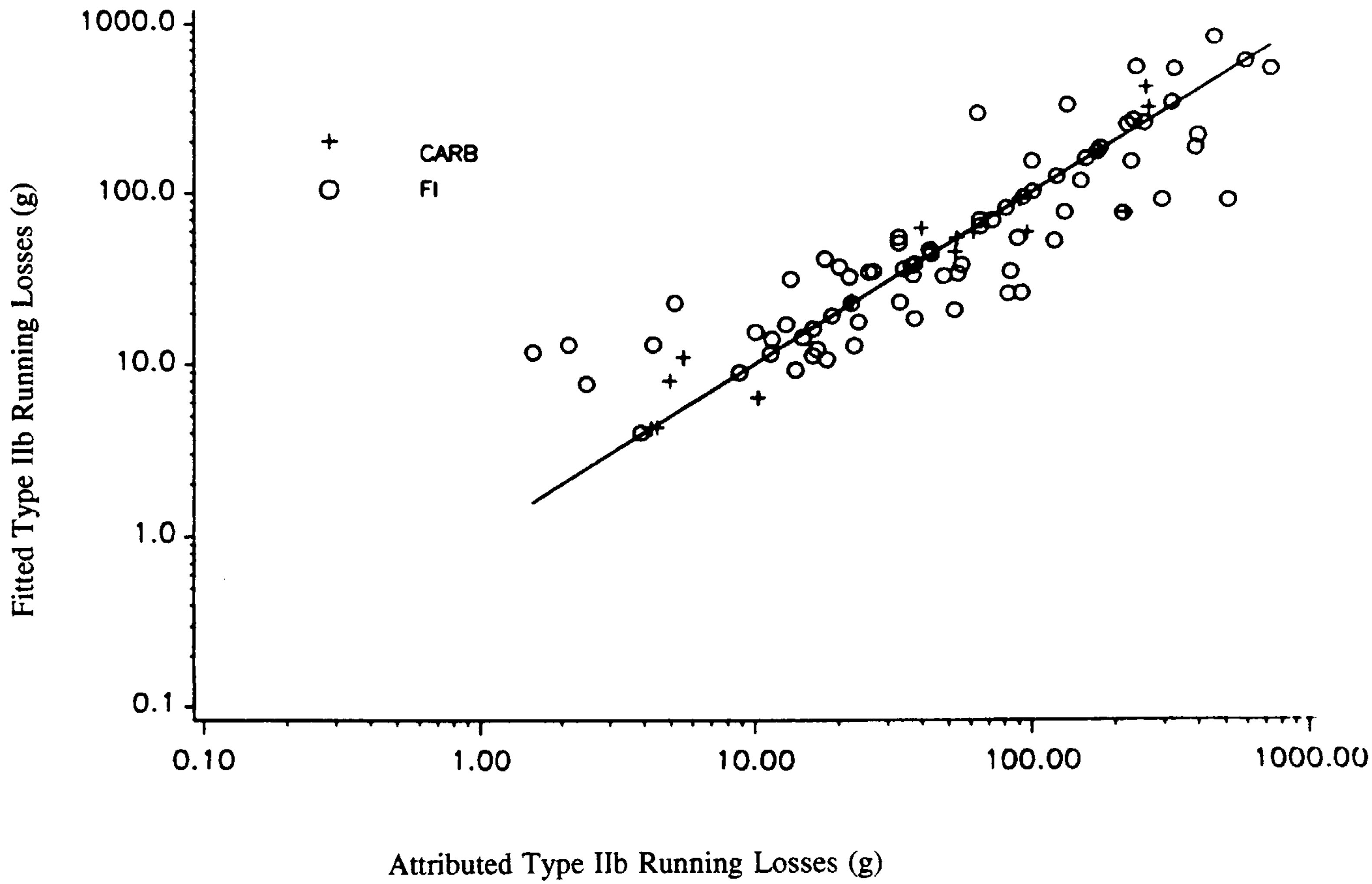
RVP	Temperature (°F) 80	95	105
7.0	-	-	1.9
9.0	0.2	1.0	14.0
11.7	2.5	18.0	-

Fuel Injected Vehicles

RVP	Temperature (°F) 80	95	105
7.0	-	0.9	1.4
9.0	1.1	1.0	3.4
11.7	1.5	24.0	-

To show how well this regression relationship fits the Running Loss emissions data for this EPA subset, a parity plot of the fitted versus the estimated Type IIb Running Loss emissions is shown in Figure 18. Different symbols are used for the fuel-injected and carbureted vehicles. It can be seen that, while the regressed and attributed Running Loss emissions form a linear relationship, a considerable amount of the variability is not explained by the regression model. This can be derived from different sources. The separation of the total emissions into fugitive and Running Loss emissions may not be accurate. The assumption that all of the vehicles respond the same to temperature and RVP, and can be offset by multiplicative factors may not be accurate, and the emissions themselves contain experimental error.

Figure 18
Fitted versus Attributed
Type IIb Running Loss Emissions



Modeling of Fugitive Emissions Data

The same technique that was used for the Running Loss data was used to investigate trends in fugitive emissions data. Table 14 shows the number of fugitive loss observations for both carbureted and fuel-injected observations. The regression expression is the same as that used for the Running Loss regression.

Table 14
Demonstration Model Frequencies
Fugitive Running Loss Emissions

Carbureted Vehicle Test Counts

	Temperature (°F)		
RVP	80	95	105
7.0	0	4	3
9.0	4	9	3
10.4	1	1	0
11.7	7	12	0

Fuel Injected Vehicle Test Counts

	Temperature (°F)		
RVP	80	95	105
7.0	0	10	9
9.0	12	24	24
10.4	1	1	0
11.7	27	39	0

The fugitive emission factor results are shown in Table 15. These values are again relative to a value of 1.0 at an RVP of 9.0 and ambient temperature of 95°F. As expected, the dependence of fugitive emissions to temperature and RVP is much weaker than the Type IIb emissions because of the first cut procedure used to separate the two types.

Table 15
Fugitive Running Loss Emission Factors

Carbureted Vehicles

	Temperature (°F)		
RVP	80	95	105
7.0	-	0.9	1.8
9.0	1.4	1.0	1.5
11.7	1.1	1.4	-

Fuel Injected Vehicles

	Temperature (°F)		
RVP	80	95	105
7.0	-	0.8	1.0
9.0	0.6	1.0	1.0
11.7	0.8	1.4	-

A parity plot of the fitted and estimated fugitive loss emissions data is shown in Figure 19. The values for fuel-injected and carbureted vehicles are plotted with different symbols. The location of these symbols indicates that the carbureted vehicles tend to have higher fugitive losses than the fuel-injected vehicles.

Comparison of Measured and Fitted Total Emissions Data

The total emissions of each vehicle, including the fugitive emissions and the Running Losses, can be predicted by summing the predictions of the two mechanisms for each vehicle. When the total emissions level is low, the emissions are dominated by the fugitives, and when the total emissions level is high, emissions are dominated by the Running Losses. A parity plot of the total emissions measured for the vehicles in the subset against the fitted emissions by the sum of the two mechanisms is shown in Figure 20.

This plot shows that over the wide range of cumulative hydrocarbons at Bag 6, the sum of the regressions for the two mechanisms predicts the emissions of the individual vehicles well for total emissions greater than about 10 grams. For measured values below 10 grams, the sum of the regression over predicts the measured values.

The Running Loss model is based on data from only those vehicle tests where total emissions were high; that is where Running Losses dominate the total emissions. The Running Losses at mild conditions (that is, where total emissions are less than 10 grams) were assigned missing values for the purposes of regression since they are not known precisely; however, they are known to be small. Thus, predictions of Running Loss

Figure 19
Fitted versus Attributed
Fugitive Running Loss Emissions

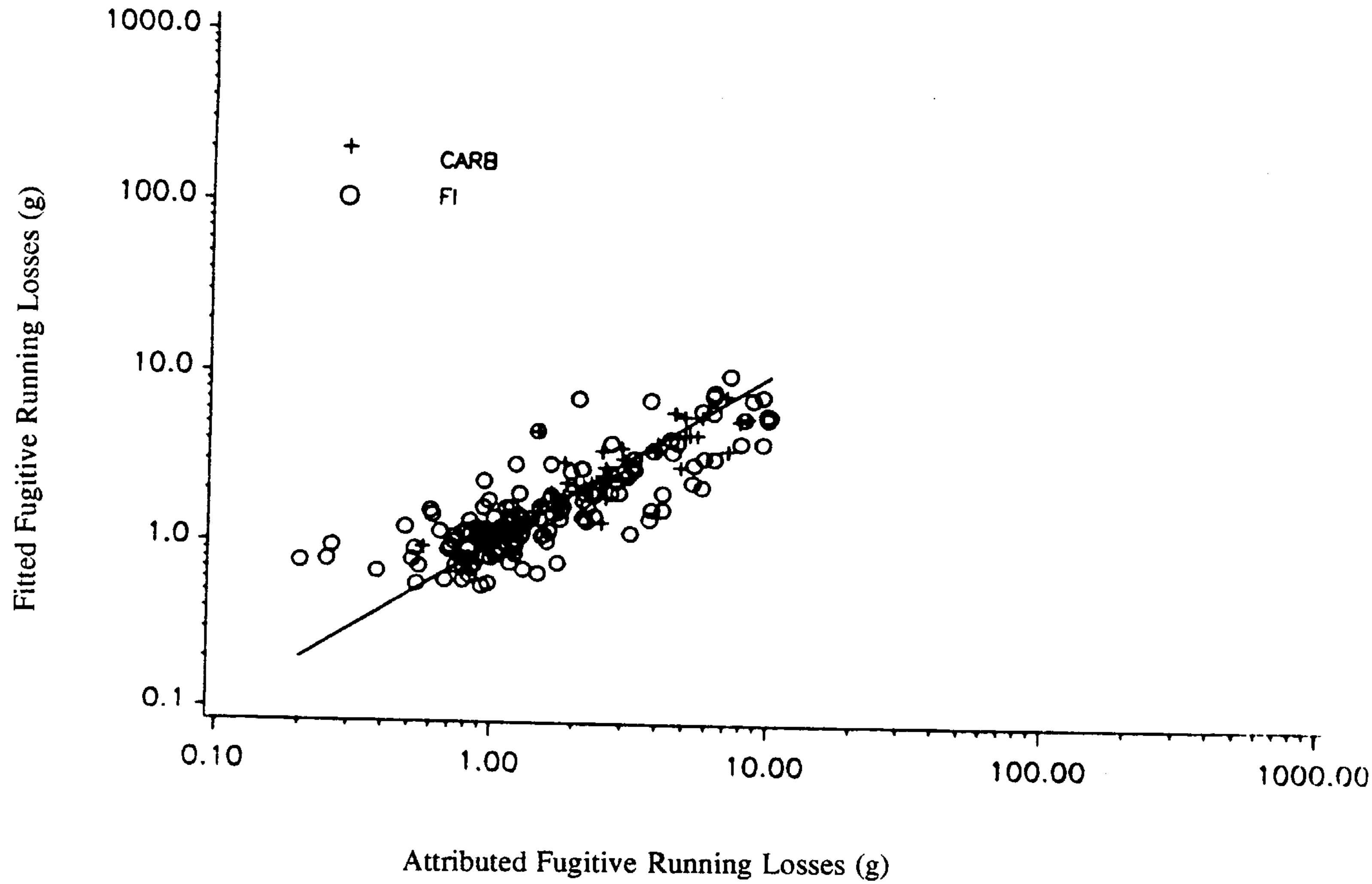
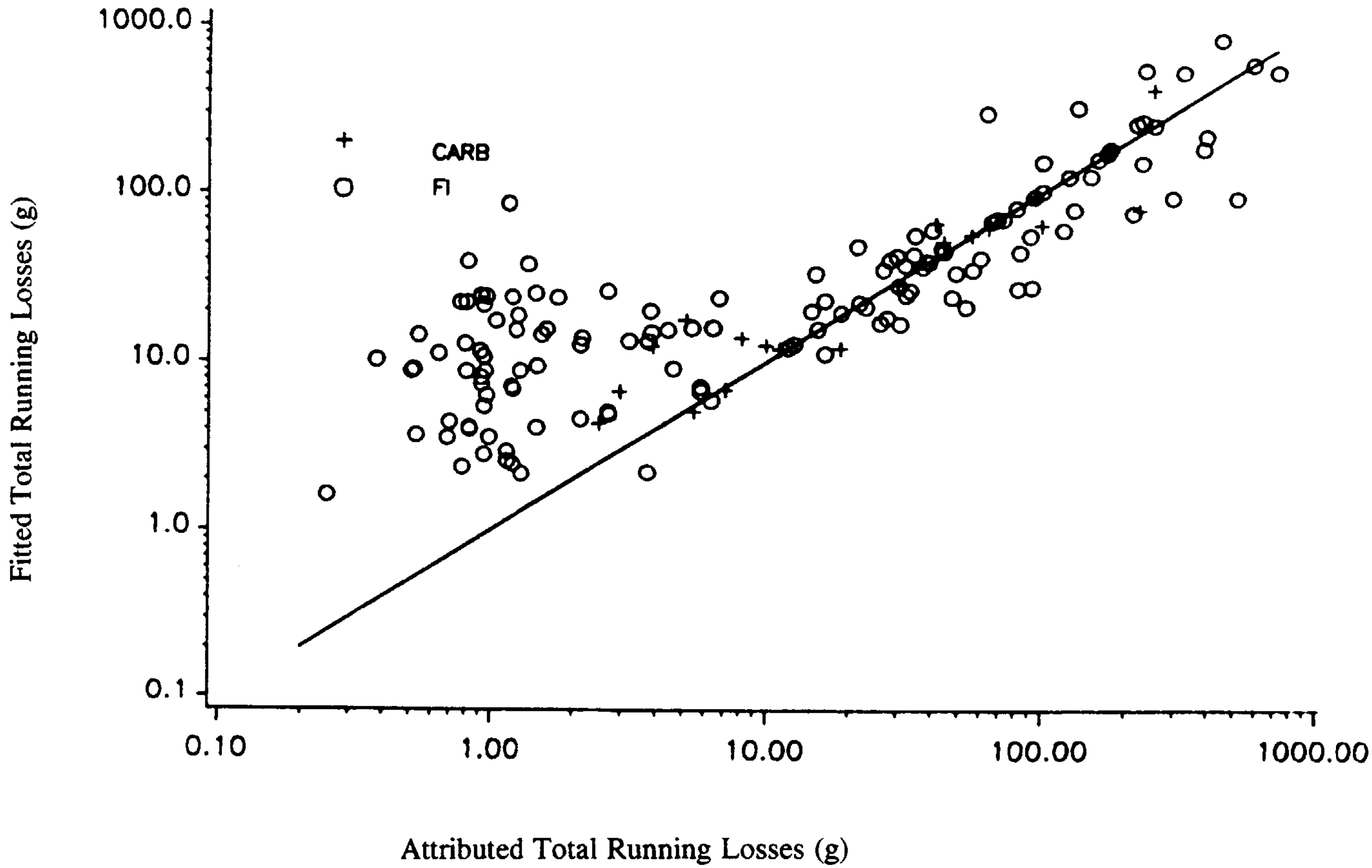


Figure 20
Fitted versus Attributed
Total Running Loss Emissions
(Fugitive + Type IIb)



emissions by this model at mild conditions is an extrapolation of the model. In this case, the model over predicts the Running Losses in this region of extrapolation.

This anomalous behavior of the model can be remedied by assigning different values to the attributed Running Losses at the mild conditions. This must be done so that the emission factors derived from the severe condition Running Losses are not affected. An iteration of regressions is called for, but has not been done for this demonstration.

Modeling of Fleet Trends

To be useful, the models of individual vehicle emissions must be combined in an appropriate way to model the behavior of the vehicle population as a whole. This is described below by introducing the concept of the fleet average vehicle. Then, the model for individual vehicles which was derived above is extended to provide a model for the vehicle population. In the final part of this section, discussion of the various parts of a complete fleet vehicle model are made.

Fleet Average Vehicle Concept

The emissions of the vehicle population can be estimated by multiplying the number of vehicles in the fleet by the behavior of the fleet average vehicle. This vehicle will have the average dependences of all the variables important to Running Loss emissions. Because of the way in which the emissions of the individual vehicles were derived in the previous section, the fleet average vehicle will have the same dependences as the individual vehicles in the test fleet. The value of the emissions at 9.0 RVP and 95°F will be the arithmetic average of the emissions values of a representative distribution of vehicles. Only if the test fleet vehicles are characteristic of the vehicle population will this average represent the emissions of the vehicle population. Thus, it is important to include the results of vehicles which had no significant Type IIb Running Loss emissions in the average for the fleet average vehicle value.

In the case of a test fleet where data were collected in a balanced manner, that is, all vehicles were tested at all test conditions, the emission behavior of the fleet average vehicle would be the simple algebraic average of all of the emissions for all vehicles taken at each test condition. However, in the case of an unbalanced data set, such a simple arithmetic average will produce biases in the apparent response of the fleet average vehicle to changes in test conditions. The method used to avoid some of these biases is a regression of the emissions of each individual vehicle. These individual regressions will produce a fitted value for the emissions for each vehicle at the conditions of 9.0 RVP and 95°F. An average of these predicted values will produce the estimated value for the fleet average vehicle at those conditions.

For the fleet average emissions expression to be accurate, it is critical that the emissions of the vehicles which are averaged includes a representative set of vehicles of the vehicle population. Consequently, in our calculation of the demonstration model for the fleet average vehicle emissions, we include the emissions at 9.0 RVP and 95°F for vehicles which were tested at a single condition and not at other conditions because they did not produce high Running Loss emissions.

Fleet Emissions Model for this EPA Subset

The fitted individual vehicle emissions values for each of the fugitive losses and Running Losses were averaged arithmetically, that is, on a grams basis, for each of the RVP/temperature conditions. Vehicles with zero Type IIb Running Losses were also included in this average so that the average becomes our best estimate of the fleet average vehicle behavior. The results for the Type IIb Running Loss fleet average vehicle values and the fugitive loss fleet average vehicle values are shown in Tables 16 and 17 for carbureted and fuel-injected vehicles. Inspection of the corresponding cells between the Type IIb Running Loss values and the fugitive loss values shows that at low severity conditions, the fugitive losses are greater than the total Running Losses. However, at more extreme conditions of temperature and RVP, the Running Losses dominate the fugitive losses.

Table 16
Type IIb Running Loss Fleet Average Vehicle

Carbureted Fleet Average Vehicle (grams)

	Temperature (°F)		
RVP	80	95	105
7.0	-	-	6.6
9.0	0.7	3.6	48
11.7	9.0	63	-

Fuel Injected Fleet Average Vehicle (grams)

	Temperature (°F)		
RVP	80	95	105
7.0	-	5.9	9.3
9.0	6.8	6.5	22.0
11.7	9.7	154	-

Table 17
Fugitive Running Loss Fleet Average Vehicle

Carbureted Fleet Average Vehicle (grams)

	Temperature (°F)		
RVP	80	95	105
7.0	-	2.0	4.0
9.0	3.1	2.3	3.3
11.7	2.5	3.2	-

Fuel Injected Fleet Average Vehicle (grams)

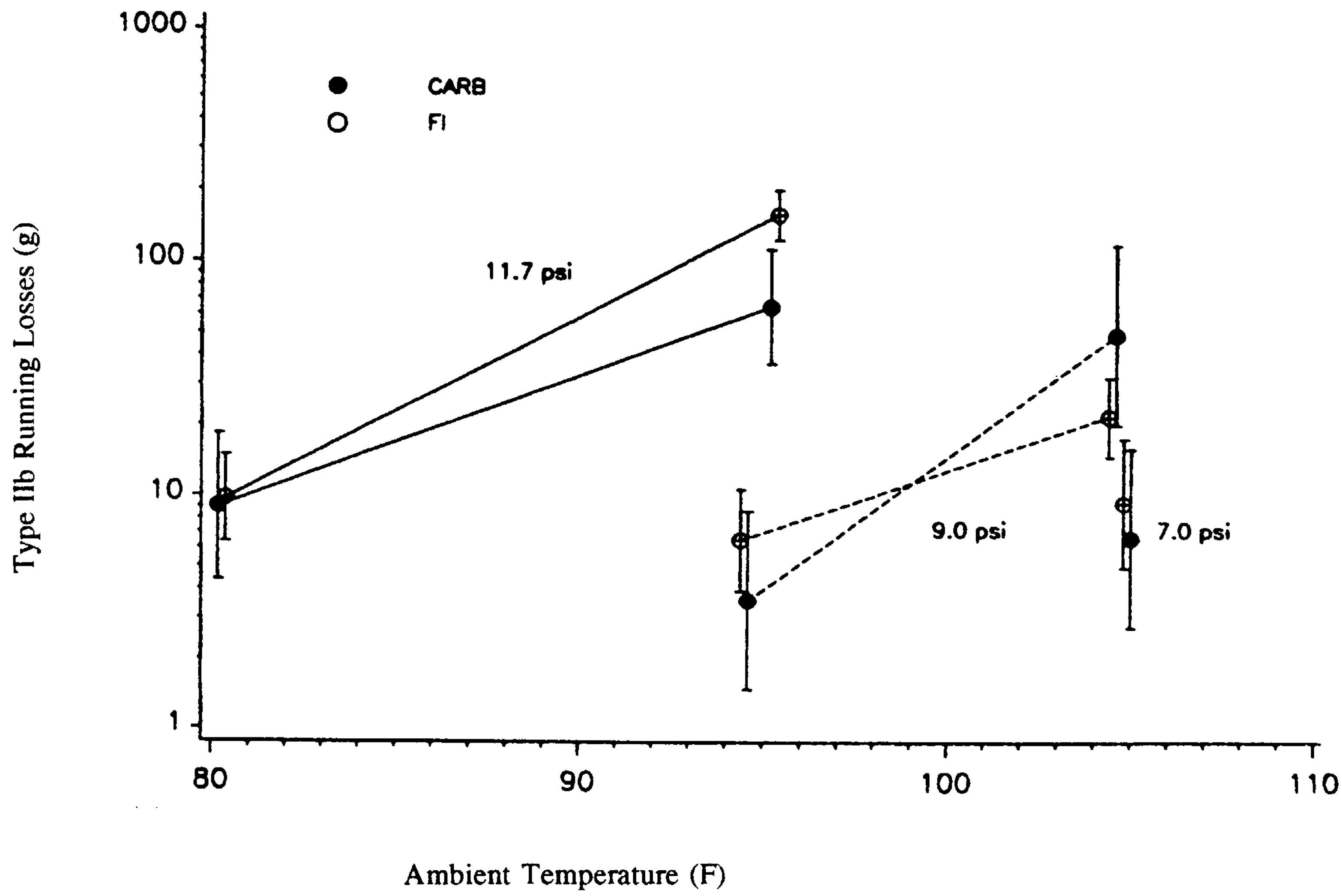
	Temperature (°F)		
RVP	80	95	105
7.0	-	1.5	1.9
9.0	1.1	1.9	1.9
11.7	1.6	2.7	-

Inspection of Table 16 shows that the Type IIb Running Loss values are strongly dependent on temperature and RVP, especially at the more extreme conditions. The fugitive Running Loss values in Table 17 show weaker temperature and RVP dependence.

At this point, it is important to consider the uncertainty in these fleet average vehicle values. The values with error bars provide the targets for continuous functions in RVP and temperature to pass through. The continuous functions are the desired product of the data analysis. From them, the Running Losses at any reasonable condition can be estimated.

The uncertainties have been estimated from the data by multiplying the measured Running Loss emissions for each vehicle by the ratio of the fleet average vehicle value at 9.0 RVP/95°F divided by the fitted value of the Running Loss emissions at 9.0 RVP/95°F. In this way, the measurements on all of the vehicles become surrogates for multiple measurements taken on the fleet average vehicle. These corrected values are again regressed using class regression against all combinations of RVP and temperature. The results of the regression provide estimates of the uncertainty in the fleet average vehicle emissions value at each test condition. Type IIb Running Loss values and their uncertainties are shown for the fleet average vehicle in Figure 21. The error bars are plus and minus two standard deviations of the mean. Both fuel injected and carbureted fleet average vehicle values are shown in this figure. Only those values where a sufficient number of observations are available have been shown on the figure. This figure shows a clear trend for higher Running Loss emissions as ambient temperature and RVP increase.

Figure 21
Fleet Average Vehicle
Type IIb Running Losses



The same type of plot for carbureted and fuel-injected fugitive losses is shown in Figure 22. These fleet average values show a weak tendency to increase fugitive losses as ambient temperature and RVP increase. It is also apparent that carbureted vehicles have a weak tendency to have higher fugitive losses than fuel- injected vehicles.

To determine the effect of time on emissions, this entire analysis can be repeated for each of the cumulative emissions obtained at each bag in all the test sequences. Thus, for example, the cumulative emissions of Bags 1, 2, and 3 can be used to determine the effect of severity on emissions halfway through the test sequences. By doing all these analyses, and knowing the length of time needed to collect data on each of the cumulative emissions at each bag, the relationship between the total emissions for the fleet average vehicle and severity can be obtained versus time. This is shown in Figure 23 as a series of curves with increasing total emissions for the higher cumulative bag results. By examining the response of the fleet average vehicle at a certain severity, the effect of time on these emissions can be determined from the graph.

Description of a Complete Running Loss Model

This demonstration model has been derived for carbureted and fuel- injected 1981+ LDVs and LDT1s that have passed the check of the evaporative emissions control system and were driving the LA-4 test sequence. Since this model is for demonstrations purposes only, the results of this model are not accurate and should not be viewed as descriptive of Fleet Running Losses. In the same way, other parts of the fleet can be modeled to evaluate their effects on total Running Loss emissions. These would include different driving cycles, different model year groups, and for vehicles with malfunctioning and tampered emission control systems.

Figure 22
Fleet Average Vehicle
Fugitive Running Losses

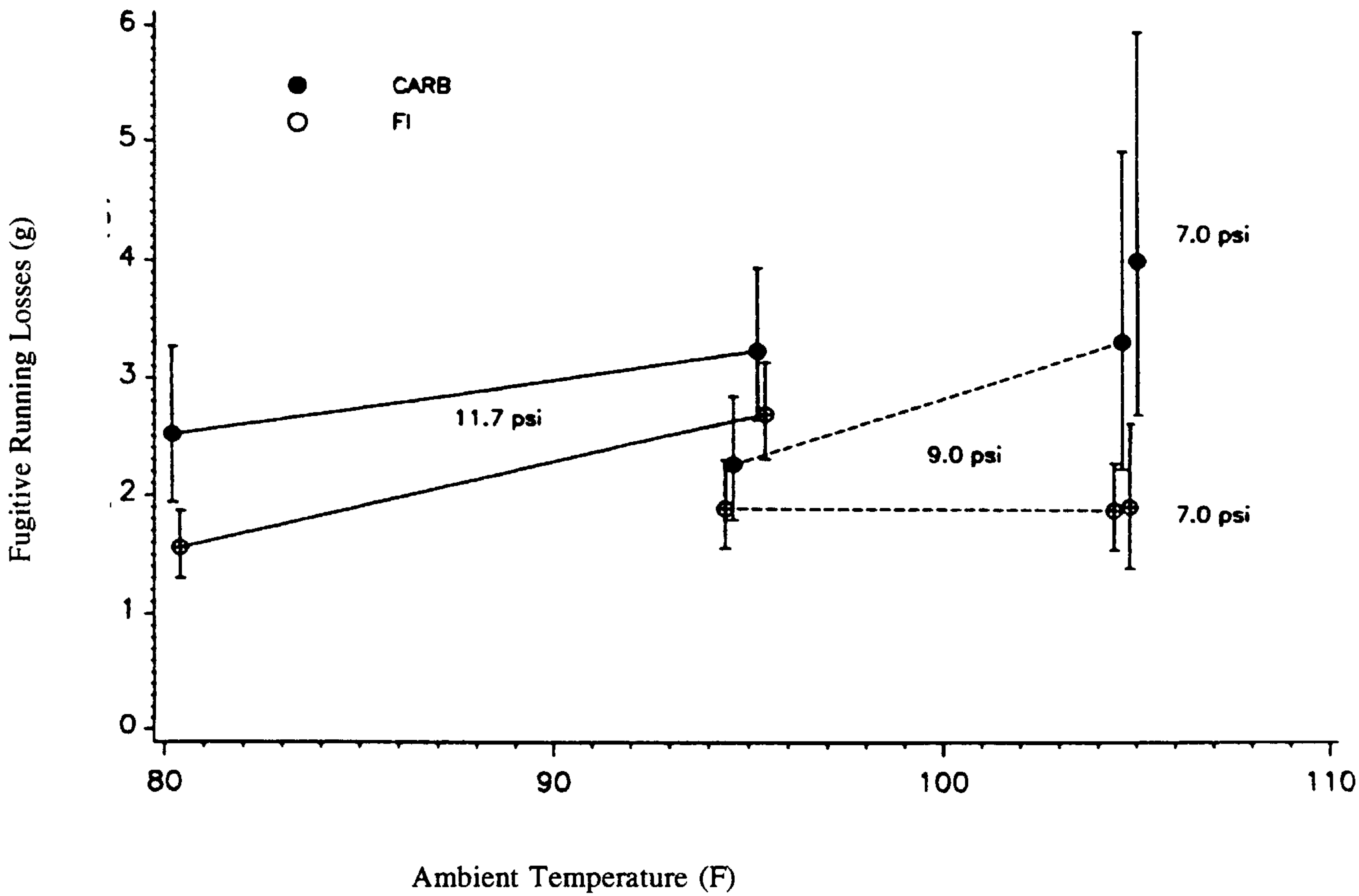
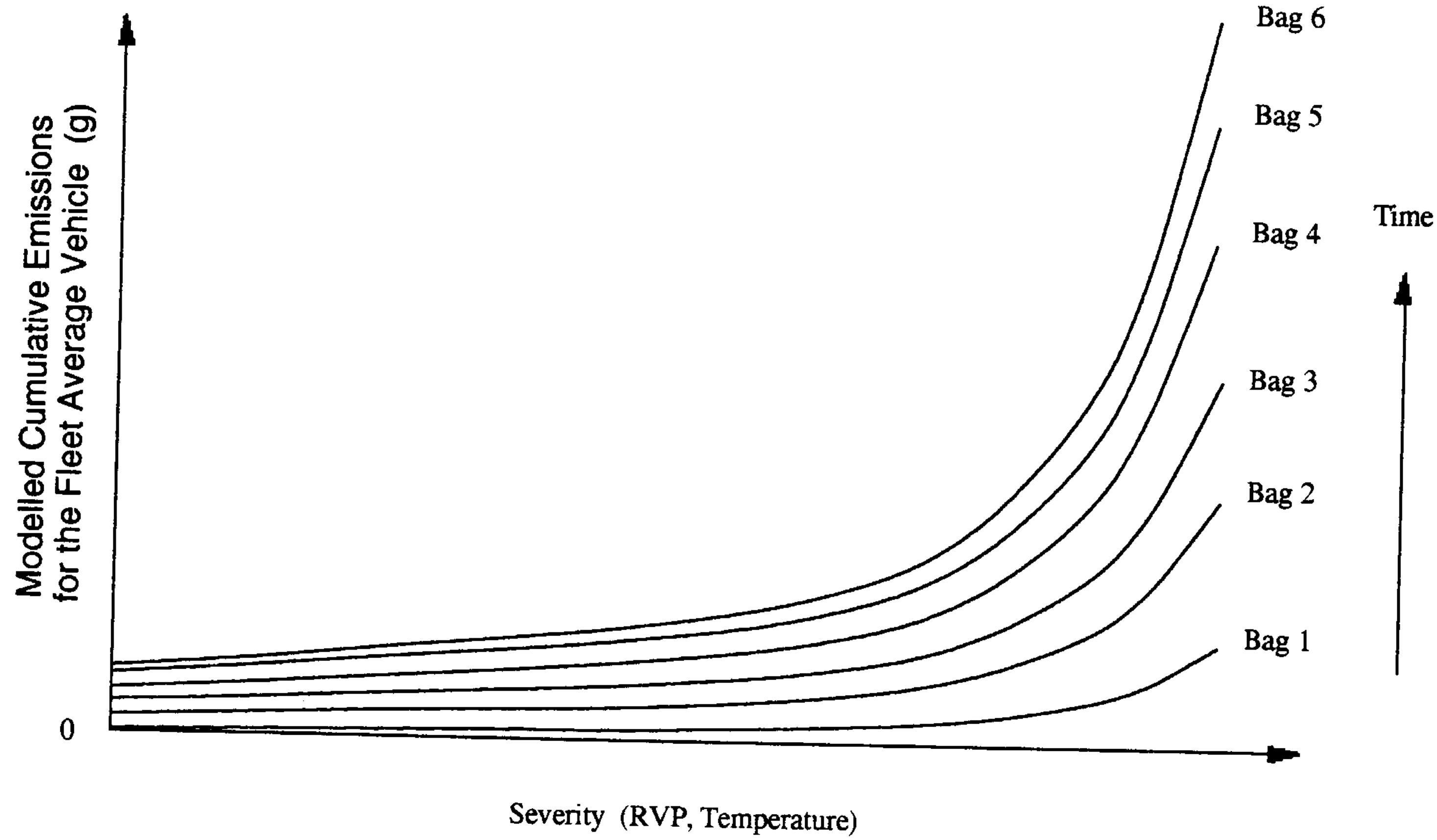


Figure 23
Fleet Average Vehicle Running Loss Emissions
Individual Bag/Time Relationship



C. Examination of ARB Data

In this section, the results of the tests on the ARB vehicles are examined for trends in the data. These results are tabulated in Appendices A, B, and C. In the following discussion, the data are examined using a different approach from that demonstrated with the EPA data.

Observations of Trends in ARB Data

The ARB data set is smaller than the EPA data set. Because of the emphasis on conducting measurements on a substantial number of vehicles at several different test conditions and choosing conditions for each vehicle based on vehicle results as they are obtained, the ARB data set is an unbalanced data set. Because of this, the analysis of the data is not straightforward.

Distribution of Emissions Values by Model Year

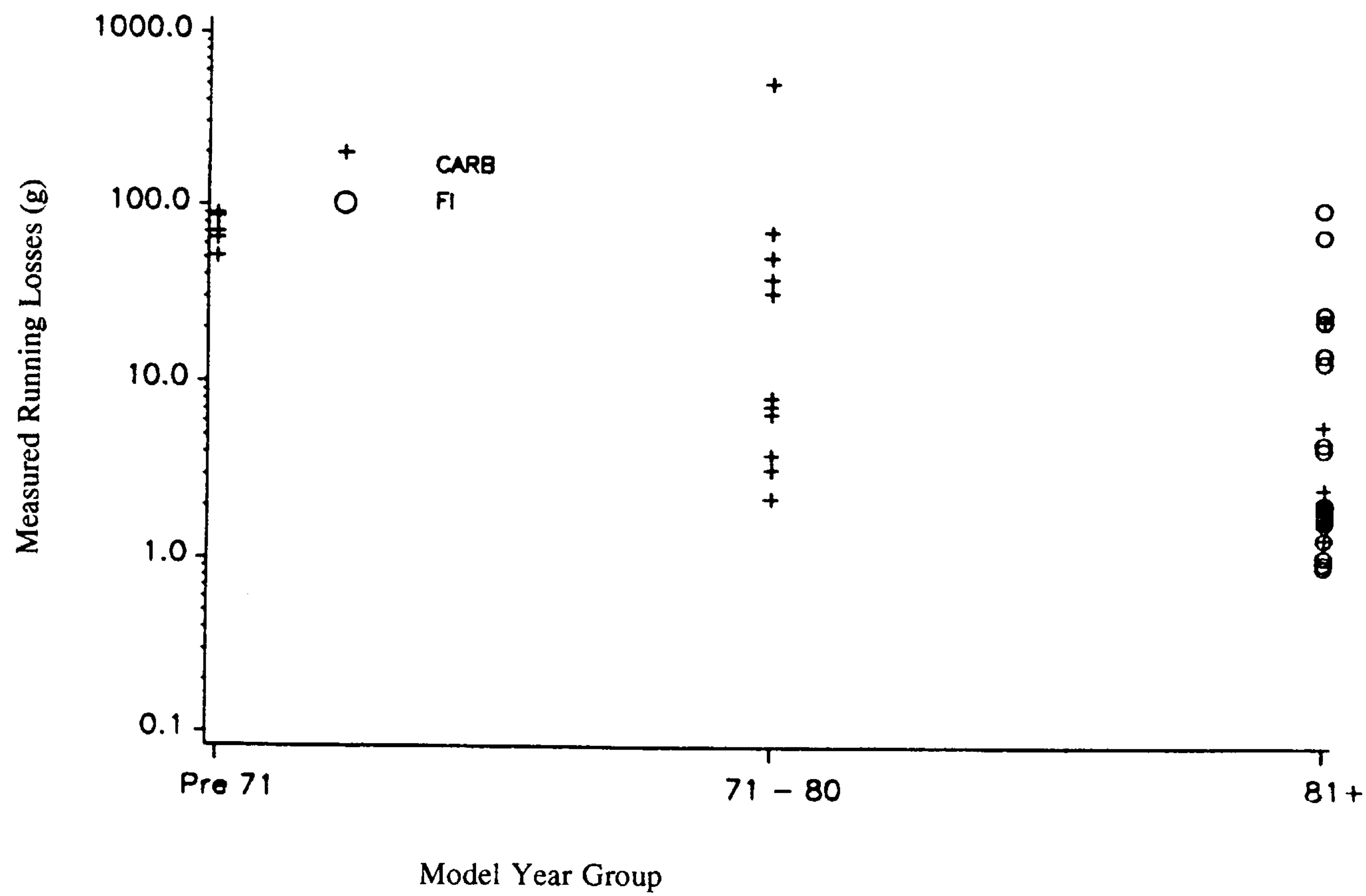
In contrast to the EPA data set, the ARB data was obtained from vehicles with a wider range of model years. For this analysis, the model years were arbitrarily divided into three groups: pre-1971, 1971-1980, and 1981+ vehicles. The first two model year groups are made up entirely of carbureted vehicles, and the 1981+ group contains both carbureted and fuel-injected vehicles.

To get an idea of the distribution of emission values for these vehicles, the measured Bag 6 cumulative Running Loss emissions at RVP 9.0, 95°F, and LA-4 sequence are plotted in Figure 24 by model year group. Each plotted value represents one vehicle.

In the pre-1971 group, the total Running Loss emissions on the few vehicles tested form a narrow distribution at a high level. In the 1971-1980 model year group, when evaporative emission control systems were introduced in the fleet, the Running Loss emissions form a wide range from low to high values. In the 1981+ model year group, fuel-injected vehicles dominate; however, the spread of Running Losses is still large.

It is important to recognize that the range of Running Loss emissions for this group of vehicles, from the highest emitting to the lowest emitting is a factor of 500. Since all the data for this comparison were taken under the same temperature, RVP, and driving cycle conditions, it is clear that the dependences on those variables alone will not provide a good model of the fleet as a whole. The fleet model must contain separate models or offsets to account for vehicle-to-vehicle variability in Running Loss emissions. It is also important to recognize that analysis of this ARB data to elucidate the RVP, temperature, and driving cycle trends must take into account the large differences between vehicles. To ignore these

Figure 24
Measure Running Losses vs. Model Year Group
ARB Vehicles 9.0 RVP / 95°F / LA-4



differences could introduce large biases in the RVP, temperature, and driving cycle emission factors.

Main Effect Contrast Examination

The ARB data can be used to get an idea of the effects of the variables on the Running Losses. In this section, this is accomplished by considering vehicles where all variables are held constant except for one. Comparison of the cumulative Running Loss emissions at Bag 6 for the two results for each vehicle are examined to see if the change in the one parameter from its low value to its high value produces an increase or a decrease in emissions. By considering all vehicles where such data pairs occur, it is possible to get an indication of the trend.

Because of the unbalanced nature of the data set, it is also important to examine the vehicles and the test conditions which are in each group of data to be considered for contrasts. If the vehicles or the test conditions do not represent the data set as a whole, then the conclusions reached also may not represent general trends for the vehicle population. In this section, the contrasts for the main effects are considered: RVP, temperature, and driving sequence.

Temperature Effect

The data for vehicles where only the ambient temperature changes are presented in Table 18. Twelve vehicles met this requirement. Examination of the cumulative emissions at Bag 6 show that in all but one instance, an increase in ambient temperature produced an increase in emissions. An examination of the vehicles which were tested shows that nine were carbureted and three were fuel-injected; six were pre- 1981 and six were 1981+ vehicles; all tests were conducted at an RVP of 9.0; and approximately an equal number of NYCC and LA-4 driving cycles were used.

Based on these contrasts, it seems that the Running Loss emissions increase with temperature. It is very important to recognize, however, that multiple tests were only performed on relatively high emitting vehicles. Using the contrast approach requires that the conclusion must be qualified "Running Losses increase with temperature on high emitting vehicles at 9.0 RVP". This follows from underlying assumption that vehicles displaying only fugitive Running Loss emissions at more severe conditions will display only fugitive emissions at less severe conditions.

Table 18
Temperature Contrasts

Vehicle	RVP	Temp	Cycle	Cum
ARB-2	9.0	95	LA-4	1.83
ARB-2	9.0	105	LA-4	2.06
SB-6	9.0	95	LA-4	1.34
SB-6	9.0	105	LA-4	24.34
SB-7	9.0	95	LA-4	1.90
SB-7	9.0	105	LA-4	2.26
SB-10	9.0	95	NYCC	7.52
SB-10	9.0	105	NYCC	12.17
SB-12	9.0	95	LA-4	64.71
SB-12	9.0	105	LA-4	153.31
SB-12	9.0	95	NYCC	86.40
SB-12	9.0	105	NYCC	162.20
SB-16	9.0	95	LA-4	89.47
SB-16	9.0	105	LA-4	122.36
SB-18	9.0	95	LA-4	13.42
SB-18	9.0	105	LA-4	19.84
SB-19	9.0	95	NYCC	16.45
SB-19	9.0	105	NYCC	141.02
SB-26	9.0	95	NYCC	63.43
SB-26	9.0	105	NYCC	105.80
SB-29	9.0	95	NYCC	78.76
SB-29	9.0	105	NYCC	72.45
SB-30	9.0	95	LA-4	37.90
SB-30	9.0	105	LA-4	76.80
SB-35	9.0	95	LA-4	4.31
SB-35	9.0	105	LA-4	91.80

RVP Effects

The vehicles which display RVP contrasts are shown in Table 19. Thirteen vehicles are in this group. Examination of the cumulative Running Loss emissions at Bag 6 show that, in all but one instance, an increase in RVP produced an increase in Running Loss emissions. However, some of those increases were small. The data set was made up of eleven carbureted vehicles and six fuel-injected vehicles. Five of the vehicles were pre-1981 and eight were 1981+ and, finally, the combinations of temperature and trip were dominated by 95°F LA-4s and 105°F NYCCs.

Table 19
RVP Contrasts

Vehicle	RVP	Temp	Cycle	Cum
ARB-2	7.5	95	LA-4	1.68
ARB-2	9.0	95	LA-4	1.83
ARB-5	7.5	95	LA-4	1.17
ARB-5	9.0	95	LA-4	1.33
SB-10	7.5	95	LA-4	7.68
SB-10	9.0	95	LA-4	7.28
SB-12	7.5	95	LA-4	64.68
SB-12	9.0	95	LA-4	64.71
SB-16	7.5	105	NYCC	52.48
SB-16	9.0	105	NYCC	113.49
SB-17	7.5	105	NYCC	37.04
SB-17	9.0	105	NYCC	95.32
SB-18	7.5	105	NYCC	9.73
SB-18	9.0	105	NYCC	41.30
SB-19	7.5	105	NYCC	81.16
SB-19	9.0	105	NYCC	141.02
SB-20	7.5	105	NYCC	8.72
SB-20	9.0	105	NYCC	9.97
SB-22	7.5	105	NYCC	81.21
SB-22	9.0	105	NYCC	158.81
SB-24	7.5	105	NYCC	23.26
SB-24	9.0	105	NYCC	62.29
SB-25	7.5	105	NYCC	41.20
SB-25	9.0	105	NYCC	100.34
SB-33	7.5	95	NYCC	26.94
SB-33	9.0	95	NYCC	31.18

Driving Cycle Effects

For this data subset, the vehicle fuel metering type and model year groups are well represented. The ambient temperature and trip types were also well represented. However, the absence of 95°F NYCCs and 105°F LA-4s may be a concern.

The group of data which shows driving cycle contrasts is presented in Table 20. There are 17 vehicles in this group, which seems to be well represented for fuel metering type, model year group, RVP, temperature, and driving cycle. Examination of the cumulative

Table 20
Driving Cycle Type Contrasts

Vehicle	RVP	Temp	Cycle	Cum
ARB-2	9.0	95	LA-4	1.83
ARB-2	9.0	95	NYCC	2.18
ARB-5	9.0	95	LA-4	1.33
ARB-5	9.0	95	NYCC	1.02
SB-10	9.0	95	LA-4	7.28
SB-10	9.0	95	NYCC	7.52
SB-12	9.0	95	LA-4	64.71
SB-12	9.0	95	NYCC	86.40
SB-12	9.0	105	LA-4	153.31
SB-12	9.0	105	NYCC	162.20
SB-16	9.0	105	LA-4	122.36
SB-16	9.0	105	NYCC	113.49
SB-17	7.5	105	LA-4	60.92
SB-17	7.5	105	NYCC	37.04
SB-18	9.0	105	LA-4	19.59
SB-18	9.0	105	NYCC	41.30
SB-19	7.5	105	LA-4	17.95
SB-19	7.5	105	NYCC	81.16
SB-19	9.0	95	LA-4	23.02
SB-19	9.0	95	NYCC	16.45
SB-22	7.5	105	LA-4	70.00
SB-22	7.5	105	NYCC	81.21
SB-24	7.5	105	LA-4	24.70
SB-24	7.5	105	NYCC	23.26
SB-25	7.5	105	LA-4	32.28
SB-25	7.5	105	NYCC	41.20
SB-26	9.0	95	LA-4	69.95
SB-26	9.0	95	NYCC	63.43
SB-27	9.0	95	LA-4	86.14
SB-27	9.0	95	NYCC	208.50
SB-29	9.0	95	LA-4	51.00
SB-29	9.0	95	NYCC	78.76
SB-30	9.0	105	LA-4	76.80
SB-30	9.0	105	NYCC	91.18
SB-33	9.0	95	LA-4	25.52
SB-33	9.0	95	NYCC	31.18
SB-35	9.0	105	LA-4	91.80
SB-35	9.0	105	NYCC	85.83

Running Loss emissions for each vehicle indicates that the NYCC cycle has higher emissions than the LA-4 cycle about two-thirds of the time, and some of these comparisons are very close. Thus, it can be concluded that the NYCC cycle has slightly higher emissions than the LA-4 cycle for this group of vehicles.

APPENDICES

Appendix A
Detailed Running Loss Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	Fuel Temp Target	Fuel Temp Actual	RL - grams Phase	RL - grams Cum	RL - grams/mile Phase	RL - grams/mile Cum
ARB-1	9.0	95	LA-4	09-20-89	1	95	99	0.61	0.61	0.17	0.17
					2		106	1.09	1.70	0.28	0.23
					3	110	110	0.90	2.60	0.25	0.23
					4		115	1.65	4.24	0.42	0.28
					5		118	1.17	5.41	0.32	0.29
					6	117	120	1.65	7.05	0.42	0.31
ARB-1	9.0	95	LA-4	09-21-89	1	95	97	0.37	0.37	0.10	0.10
					2		106	0.45	0.82	0.12	0.11
					3	110	110	0.35	1.16	0.10	0.10
					4		115	0.66	1.83	0.17	0.12
					5		116	0.32	2.15	0.09	0.12
					6	117	117	0.42	2.57	0.11	0.11
ARB-2	9.0	95	LA-4	09-15-89	1	95	98	0.34	0.34	0.09	0.09
					2		106	0.35	0.69	0.09	0.09
					3	110	110	0.29	0.98	0.08	0.09
					4		114	0.29	1.27	0.08	0.08
					5		115	0.27	1.54	0.07	0.08
					6	117	117	0.29	1.83	0.08	0.08
ARB-2	9.0	105	LA-4	09-22-89	1	105	109	0.36	0.36	0.10	0.10
					2		116	0.38	0.74	0.10	0.10
					3	120	121	0.34	1.08	0.09	0.10
					4		123	0.36	1.44	0.09	0.10
					5		125	0.28	1.72	0.08	0.09
					6	127	128	0.34	2.06	0.09	0.09
ARB-2	9.0	95	NYCC	09-23-89	1	95	98	0.56	0.56	0.49	0.49
					2		104	0.35	0.90	0.30	0.39
					3	110	110	0.32	1.22	0.27	0.35
					4		112	0.32	1.54	0.27	0.33
					5		114	0.32	1.86	0.27	0.32
					6	117	117	0.32	2.18	0.27	0.31
ARB-2	7.5	95	LA-4	09-26-89	1	95	100	0.37	0.37	0.10	0.10
					2		106	0.29	0.66	0.08	0.09
					3	110	110	0.27	0.93	0.07	0.08
					4		113	0.29	1.22	0.08	0.08
					5		115	0.21	1.43	0.06	0.08
					6	117	117	0.24	1.68	0.06	0.08
ARB-3	9.0	95	LA-4	09-18-89	1	95	98	3.18	3.18	0.88	0.88
					2		105	9.09	12.27	2.52	1.70
					3	110	110	5.30	17.57	1.47	1.62
					4		113	4.57	22.15	1.18	1.51
					5		115	1.11	23.26	0.31	1.27
					6	117	117	0.22	23.48	0.06	1.06

Appendix A
Detailed Running Loss Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	Fuel Temp Target	Fuel Temp Actual	RL - grams Phase	RL - grams Cum	RL - grams/mile Phase	RL - grams/mile Cum
ARB-4	9.0	95	LA-4	09-14-89	1	95	99	0.53	0.53	0.15	0.15
					2		109	1.27	1.80	0.32	0.24
					3	110	113	1.25	3.05	0.35	0.27
					4		114	0.40	3.44	0.10	0.23
					5		116	0.29	3.73	0.08	0.20
					6	117	118	0.66	4.40	0.17	0.20
ARB-4	9.0	95	LA-4	09-21-89	1	95	102	0.48	0.48	0.13	0.13
					2		113	0.66	1.15	0.17	0.15
					3	110	115	0.16	1.30	0.04	0.12
					4		116	0.45	1.75	0.12	0.12
					5		116	0.21	1.96	0.06	0.11
					6	117	117	0.29	2.25	0.08	0.10
ARB-5	9.0	95	LA-4	09-20-89	1	95	102	0.32	0.32	0.09	0.09
					2		109	0.27	0.59	0.07	0.08
					3	110	112	0.16	0.75	0.04	0.07
					4		115	0.24	0.99	0.06	0.07
					5		117	0.16	1.14	0.04	0.06
					6	117	118	0.19	1.33	0.05	0.06
ARB-5	9.0	105	NYCC	09-22-89	1	105	110	0.97	0.97	0.80	0.80
					2		115	0.28	1.25	0.23	0.52
					3	120	120	0.29	1.54	0.24	0.42
					4		122	0.41	1.96	0.34	0.40
					5		125	1.49	3.44	1.23	0.57
					6	127	127	2.58	6.02	2.15	0.83
ARB-5	7.5	95	LA-4	09-26-89	1	95	99	0.30	0.30	0.08	0.08
					2		107	0.24	0.53	0.06	0.07
					3	110	111	0.14	0.67	0.04	0.06
					4		113	0.18	0.85	0.05	0.06
					5		116	0.13	0.99	0.04	0.05
					6	117	117	0.19	1.17	0.05	0.05
ARB-5	9.0	95	NYCC	09-27-89	1	95	100	0.21	0.21	0.18	0.18
					2		105	0.19	0.40	0.16	0.17
					3	110	110	0.16	0.56	0.14	0.16
					4		113	0.16	0.72	0.13	0.15
					5		114	0.16	0.88	0.14	0.15
					6	117	117	0.13	1.02	0.11	0.14
ARB-6	9.0	95	LA-4	09-21-89	1	95	98	0.47	0.47	0.13	0.13
					2		106	0.61	1.08	0.16	0.15
					3	110	111	0.40	1.48	0.11	0.13
					4		113	0.66	2.14	0.17	0.14
					5		114	0.37	2.51	0.10	0.14
					6	117	118	0.72	3.23	0.18	0.14

Appendix A
Detailed Running Loss Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	Fuel Temp Target	Fuel Temp Actual	RL - grams Phase	RL - grams Cum	RL - grams/mile Phase	RL - grams/mile Cum
ARB-6	9.0	95	LA-4	09-22-89	1	95	100	1.12	1.12	0.31	0.31
					2		106	3.56	4.68	0.91	0.62
					3	110	111	2.54	7.21	0.70	0.65
					4		114	3.58	10.79	0.92	0.72
					5		117	1.25	12.05	0.35	0.65
					6	117	118	2.72	14.77	0.69	0.65
SB-1	9.0	95	LA-4	10-17-89	1	95	97	0.24	0.24	0.07	0.07
					2		106	0.37	0.61	0.10	0.08
					3	110	111	0.29	0.90	0.08	0.08
					4		114	0.29	1.19	0.07	0.08
					5		116	0.16	1.35	0.05	0.07
					6	117	117	0.23	1.59	0.06	0.07
SB-2	9.0	95	LA-4	10-05-89	1	95	101	0.21	0.21	0.06	0.06
					2		105	0.37	0.58	0.09	0.08
					3	110	110	0.27	0.84	0.07	0.08
					4		112	0.32	1.16	0.08	0.08
					5		116	0.21	1.37	0.06	0.07
					6	117	117	0.26	1.63	0.07	0.07
SB-3	9.0	95	LA-4	10-17-89	1	95	96	0.90	0.90	0.25	0.25
					2		102	1.44	2.34	0.37	0.31
					3	110	108	0.87	3.21	0.24	0.29
					4		116	1.14	4.35	0.29	0.29
					5		116	0.72	5.07	0.20	0.27
					6	117	117	0.80	5.86	0.20	0.26
SB-4	9.0	95	LA-4	10-06-89	1	95	101	0.26	0.26	0.07	0.07
					2		107	0.42	0.68	0.11	0.09
					3	110	110	0.37	1.05	0.10	0.10
					4		113	0.37	1.42	0.09	0.10
					5		114	0.27	1.69	0.07	0.09
					6	117	117	0.34	2.02	0.09	0.09
SB-5	9.0	95	LA-4	10-27-89	1	95	98	0.27	0.27	0.07	0.07
					2		109	0.24	0.50	0.06	0.07
					3	110	112	0.16	0.66	0.04	0.06
					4		117	0.19	0.85	0.05	0.06
					5		120	0.13	0.98	0.04	0.05
					6	117	124	0.19	1.17	0.05	0.05
SB-6	9.0	95	LA-4	03-06-90	1	100	101	0.29	0.29	0.08	0.08
					2	107	108	0.35	0.65	0.09	0.09
					3	110	110	0.22	0.86	0.06	0.08
					4	116	117	0.32	1.18	0.08	0.08
					5	116	116	0.19	1.37	0.05	0.07
					6	118	119	0.30	1.67	0.08	0.07

Appendix A
Detailed Running Loss Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	Fuel Temp Target	Fuel Temp Actual	RL - grams Phase	RL - grams Cum	RL - grams/mile Phase	RL - grams/mile Cum
SB-6	9.0	95	LA-4	03-08-90	1	100	99	0.19	0.19	0.05	0.05
					2	107	108	0.29	0.48	0.08	0.06
					3	110	112	0.19	0.67	0.05	0.06
					4	116	115	0.24	0.91	0.06	0.06
					5	116	118	0.21	1.12	0.06	0.06
					6	118	120	0.21	1.34	0.06	0.06
SB-6	9.0	105	LA-4	03-16-90	1	110	109	0.18	0.18	0.05	0.05
					2	117	117	3.52	3.70	0.91	0.50
					3	120	121	2.66	6.36	0.74	0.58
					4	126	126	9.39	15.75	2.44	1.06
					5	126	127	8.59	24.34	2.40	1.32
					6	128	129	0.00	24.34	0.00	1.09
SB-7	9.0	95	LA-4	03-15-90	1	100	102	0.21	0.21	0.06	0.06
					2	111	110	0.37	0.58	0.10	0.08
					3	116	116	0.26	0.84	0.07	0.08
					4	120	120	0.42	1.26	0.11	0.09
					5	122	123	0.26	1.53	0.07	0.08
					6	123	124	0.37	1.90	0.10	0.09
SB-7	9.0	105	LA-4	03-19-90	1	110	112	0.24	0.24	0.07	0.07
					2	121	121	0.45	0.68	0.12	0.09
					3	126	124	0.32	1.00	0.09	0.09
					4	130	130	0.45	1.44	0.12	0.10
					5	132	131	0.34	1.79	0.10	0.10
					6	133	133	0.47	2.26	0.12	0.10
SB-8	9.0	95	LA-4	04-04-90	1	102	100	0.18	0.18	0.05	0.05
					2	115	116	0.24	0.42	0.06	0.06
					3	119	122	0.13	0.55	0.04	0.05
					4	123	125	0.18	0.73	0.05	0.05
					5	126	125	0.11	0.84	0.03	0.05
					6	127	126	0.21	1.05	0.05	0.05
SB-10	9.0	95	LA-4	08-29-90	1	100	97	0.37	0.37	0.10	0.10
					2	107	106	2.45	2.81	0.63	0.38
					3	108	110	1.41	4.22	0.39	0.38
					4	112	110	0.82	5.04	0.21	0.34
					5	114	115	1.04	6.09	0.29	0.33
					6	116	116	1.19	7.28	0.31	0.33
SB-10	9.0	105	NYCC	08-31-90	1	108	108	2.39	2.39	1.99	1.99
					2	112	112	2.45	4.83	2.05	2.02
					3	115	115	1.92	6.75	1.59	1.87
					4	118	118	1.69	8.44	1.40	1.76
					5	121	121	1.77	10.22	1.48	1.70
					6	124	124	1.95	12.17	1.63	1.69

Appendix A
Detailed Running Loss Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	Fuel Temp Target	Fuel Temp Actual	RL - grams Phase	RL - grams Cum	RL - grams/mile Phase	RL - grams/mile Cum
SB-10	9.0	95	LA-4	09-07-90	1	100	97	0.44	0.44	0.12	0.12
					2	107	107	2.40	2.84	0.62	0.38
					3	108	109	1.40	4.24	0.39	0.38
					4	112	112	1.42	5.67	0.37	0.38
					5	114	114	0.97	6.64	0.27	0.36
					6	116	116	1.52	8.15	0.39	0.36
SB-10	9.0	95	NYCC	09-10-90	1	98	98	0.87	0.87	0.74	0.74
					2	102	102	1.53	2.40	1.28	1.01
					3	105	105	1.36	3.76	1.14	1.05
					4	108	108	1.22	4.98	1.01	1.04
					5	111	112	1.22	6.19	1.01	1.03
					6	114	114	1.33	7.52	1.10	1.05
SB-10	7.5	95	LA-4	09-12-90	1	100	97	0.35	0.35	0.10	0.10
					2	107	105	1.64	1.99	0.42	0.27
					3	108	108	1.30	3.29	0.36	0.30
					4	112	112	1.84	5.13	0.48	0.34
					5	114	114	0.93	6.05	0.26	0.33
					6	116	116	1.63	7.68	0.42	0.34
SB-11	9.0	95	LA-4	08-30-90	1	98	98	0.34	0.34	0.09	0.09
					2	105	106	0.45	0.79	0.12	0.11
					3	109	110	0.32	1.11	0.09	0.10
					4	113	112	0.40	1.51	0.10	0.10
					5	116	116	0.35	1.85	0.10	0.10
					6	119	119	0.37	2.22	0.10	0.10
SB-12	9.0	95	LA-4	09-10-90	1	100	97	5.69	5.69	1.58	1.58
					2	107	104	27.61	33.30	7.10	4.45
					3	108	111	23.78	57.08	6.60	5.15
					4	112	112	5.97	63.05	1.53	4.21
					5	114	114	1.06	64.11	0.30	3.45
					6	116	114	0.60	64.71	0.15	2.88
SB-12	9.0	95	NYCC	09-12-90	1	98	99	1.51	1.51	1.25	1.25
					2	102	99	7.33	8.84	6.15	3.69
					3	105	102	14.55	23.39	12.29	6.53
					4	108	106	20.47	43.85	17.13	9.18
					5	111	110	21.14	64.99	17.76	10.89
					6	114	114	21.41	86.40	17.93	12.07
SB-12	7.5	95	LA-4	09-13-90	1	100	96	5.67	5.67	1.58	1.58
					2	107	104	25.87	31.54	6.65	4.21
					3	108	109	22.30	53.84	6.21	4.86
					4	112	114	7.90	61.74	2.04	4.13
					5	114	116	-0.01	61.73	0.00	3.33
					6	116	117	2.95	64.68	0.76	2.89

Appendix A
Detailed Running Loss Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	Fuel Temp Target	Fuel Temp Actual	RL - grams Phase	RL - grams Cum	RL - grams/mile Phase	RL - grams/mile Cum
SB-12	9.0	105	NYCC	09-14-90	1	108	105	11.56	11.56	9.57	9.57
					2	112	109	34.01	45.57	28.23	18.89
					3	115	115	50.82	96.39	42.45	26.70
					4	118	119	38.91	135.30	32.15	28.07
					5	121	122	6.21	141.51	5.18	23.51
					6	124	122	20.69	162.20	17.26	22.47
SB-12	9.0	105	LA-4	09-18-90	1	110	106	9.39	9.39	2.60	2.60
					2	117	115	51.87	61.26	13.32	8.16
					3	118	120	10.47	71.72	2.92	6.46
					4	122	120	10.79	82.51	2.77	5.51
					5	124	125	31.12	113.63	8.67	6.12
					6	126	129	39.68	153.31	10.36	6.84
SB-12	9.0	80	LA-4	09-19-90	1	85	82	9.12	9.12	2.50	2.50
					2	92	92	26.03	35.15	6.65	4.65
					3	93	101	8.70	43.85	2.40	3.92
					4	97	106	4.78	48.63	1.21	3.22
					5	99	106	3.59	52.22	0.99	2.79
					6	101	107	4.04	56.26	1.03	2.48
SB-13	9.0	95	LA-4	09-27-90	1	101	101	13.74	13.74	3.79	3.79
					2	114	114	54.53	68.27	13.97	9.07
					3	121	122	62.27	130.55	17.34	11.74
					4	129	131	107.01	237.56	27.40	15.81
					5	133	135	78.94	316.50	22.14	17.02
					6	137	140	185.05	501.55	47.98	22.34
SB-14	9.0	95	LA-4	09-05-90	1	100	98	0.61	0.61	0.17	0.17
					2	107	104	0.95	1.56	0.25	0.21
					3	108	109	0.53	2.09	0.15	0.19
					4	112	113	0.74	2.83	0.19	0.19
					5	114	114	0.47	3.30	0.13	0.18
					6	116	115	0.59	3.89	0.15	0.17
SB-15	9.0	95	LA-4	09-17-90	1	101	100	0.24	0.24	0.07	0.07
					2	109	109	0.37	0.61	0.10	0.08
					3	113	113	0.27	0.88	0.07	0.08
					4	117	118	0.37	1.25	0.10	0.08
					5	119	120	0.24	1.49	0.07	0.08
					6	120	121	0.29	1.78	0.08	0.08
SB-16	9.0	95	LA-4	09-24-90	1	100	99	2.78	2.78	0.78	0.78
					2	108	108	21.73	24.51	5.67	3.31
					3	111	113	17.49	42.00	4.94	3.84
					4	116	114	7.30	49.30	1.92	3.34
					5	118	118	21.01	70.31	5.89	3.84
					6	121	120	19.16	89.47	4.96	4.03

Appendix A
Detailed Running Loss Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	Fuel Temp Target	Fuel Temp Actual	RL - grams Phase	RL - grams Cum	RL - grams/mile Phase	RL - grams/mile Cum
SB-16	9.0	105	NYCC	09-28-90	1	111	109	5.66	5.66	4.79	4.79
					2	117	116	18.44	24.10	15.59	10.19
					3	120	120	18.96	43.06	16.17	12.18
					4	124	123	18.07	61.13	15.30	12.96
					5	127	127	25.29	86.42	21.13	14.61
					6	130	130	27.07	113.49	23.21	16.03
SB-16	9.0	105	LA-4	10-01-90	1	110	109	5.50	5.50	1.52	1.52
					2	118	118	25.76	31.26	6.65	4.17
					3	121	121	17.65	48.91	4.91	4.41
					4	126	126	27.43	76.34	7.09	5.10
					5	128	128	15.79	92.13	4.41	4.97
					6	131	130	30.24	122.36	7.82	5.46
SB-16	7.5	105	NYCC	10-02-90	1	111	111	4.98	4.98	4.22	4.22
					2	117	117	10.69	15.66	9.06	6.64
					3	120	120	8.11	23.77	6.87	6.72
					4	124	124	9.41	33.18	7.98	7.03
					5	127	127	10.70	43.88	9.07	7.44
					6	130	130	8.60	52.48	7.28	7.41
SB-17	9.0	95	LA-4	10-01-90	1	98	99	1.03	1.03	0.29	0.29
					2	107	107	14.49	15.52	3.74	2.08
					3	112	112	14.14	29.66	3.93	2.68
					4	117	119	23.50	53.17	6.07	3.56
					5	120	123	13.37	66.54	3.73	3.59
					6	123	124	3.71	70.24	0.96	3.14
SB-17	9.0	105	NYCC	10-04-90	1	109	109	1.45	1.45	1.23	1.23
					2	115	115	17.79	19.25	14.90	8.10
					3	121	122	20.11	39.36	16.89	11.03
					4	125	124	11.62	50.98	9.75	10.71
					5	128	128	14.57	65.55	12.16	11.00
					6	131	131	29.77	95.32	24.91	13.33
SB-17	7.5	105	NYCC	10-05-90	1	109	109	0.85	0.85	0.73	0.73
					2	115	115	3.52	4.37	3.01	1.87
					3	121	121	8.37	12.74	7.06	3.62
					4	125	126	10.84	23.59	9.06	5.00
					5	128	129	8.14	31.73	6.83	5.37
					6	131	131	5.31	37.04	4.48	5.22
SB-17	7.5	105	LA-4	10-10-90	1	108	108	0.51	0.51	0.14	0.14
					2	117	117	7.67	8.18	1.98	1.10
					3	122	122	10.91	19.10	3.02	1.73
					4	127	128	17.25	36.34	4.42	2.43
					5	130	130	8.83	45.17	2.44	2.43
					6	130	133	15.75	60.92	4.03	2.71

Appendix A
Detailed Running Loss Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	Fuel Temp Target	Fuel Temp Actual	RL - grams Phase	RL - grams Cum	RL - grams/mile Phase	RL - grams/mile Cum
SB-18	9.0	95	LA-4	09-17-90	1	100	100	0.96	0.96	0.27	0.27
					2	108	109	2.38	3.34	0.61	0.45
					3	112	115	2.80	6.14	0.78	0.55
					4	118	118	2.76	8.90	0.71	0.59
					5	119	119	1.93	10.83	0.53	0.58
					6	122	123	2.59	13.42	0.66	0.60
SB-18	9.0	105	NYCC	09-19-90	1	111	111	0.99	0.99	0.83	0.83
					2	117	117	1.89	2.88	1.59	1.21
					3	121	121	2.49	5.36	2.10	1.50
					4	126	125	7.77	13.13	6.53	2.76
					5	128	128	12.36	25.49	10.44	4.29
					6	130	129	15.81	41.30	13.12	5.78
SB-18	7.5	105	NYCC	09-24-90	1	111	111	1.17	1.17	0.98	0.98
					2	117	117	1.46	2.63	1.23	1.10
					3	121	121	1.70	4.33	1.43	1.21
					4	126	126	1.74	6.07	1.45	1.27
					5	128	128	1.90	7.97	1.56	1.33
					6	130	130	1.77	9.73	1.47	1.35
SB-18	9.0	105	LA-4	09-27-90	1	110	110	0.28	0.28	0.08	0.08
					2	118	118	1.82	2.11	0.47	0.28
					3	122	122	1.69	3.79	0.47	0.34
					4	128	128	4.89	8.68	1.26	0.58
					5	129	130	7.54	16.23	2.10	0.87
					6	132	133	3.61	19.84	0.93	0.88
SB-18	9.0	105	LA-4	09-28-90	1	110	110	0.71	0.71	0.20	0.20
					2	118	117	2.41	3.12	0.62	0.42
					3	122	122	2.18	5.30	0.61	0.48
					4	128	126	3.05	8.36	0.79	0.56
					5	129	129	6.65	15.01	1.85	0.81
					6	132	132	4.58	19.59	1.18	0.87
SB-19	9.0	95	LA-4	09-13-90	1	100	102	0.63	0.63	0.18	0.18
					2	110	108	2.27	2.90	0.59	0.39
					3	113	112	2.61	5.50	0.73	0.50
					4	117	118	3.98	9.48	1.03	0.64
					5	119	120	2.36	11.84	0.66	0.64
					6	121	123	3.06	14.90	0.80	0.67
SB-19	9.0	105	NYCC	09-18-90	1	109	109	1.44	1.44	1.21	1.21
					2	113	114	3.61	5.05	3.03	2.12
					3	120	120	5.32	10.37	4.44	2.89
					4	125	125	28.96	39.33	23.66	8.19
					5	129	129	48.08	87.41	39.97	14.55
					6	132	132	53.60	141.02	45.01	19.59

Appendix A
Detailed Running Loss Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	Fuel Temp Target	Fuel Temp Actual	RL - grams Phase	RL - grams Cum	RL - grams/mile Phase	RL - grams/mile Cum
SB-19	9.0	95	NYCC	09-19-90	1	100	102	0.63	0.63	0.54	0.54
					2	110	107	1.51	2.14	1.29	0.92
					3	113	111	3.49	5.63	2.97	1.61
					4	117	116	3.62	9.25	3.09	1.98
					5	119	119	3.80	13.05	3.24	2.23
					6	121	122	3.41	16.45	2.88	2.34
SB-19	9.0	95	LA-4	09-20-90	1	100	100	1.29	1.29	0.36	0.36
					2	110	108	4.72	6.01	1.21	0.80
					3	113	113	4.19	10.20	1.16	0.92
					4	117	117	6.22	16.41	1.60	1.09
					5	119	118	0.99	17.40	0.27	0.94
					6	121	121	5.62	23.02	1.44	1.02
SB-19	7.5	105	NYCC	09-24-90	1	109	109	3.46	3.46	2.93	2.93
					2	113	114	7.92	11.38	6.70	4.82
					3	120	119	13.73	25.12	11.53	7.07
					4	125	125	17.02	42.14	14.26	8.87
					5	129	129	19.84	61.97	16.70	10.44
					6	132	132	19.19	81.16	16.07	11.38
SB-19	7.5	105	LA-4	09-27-90	1	110	109	0.91	0.91	0.25	0.25
					2	120	118	3.83	4.74	1.00	0.64
					3	123	125	3.98	8.72	1.12	0.79
					4	127	128	3.54	12.26	0.92	0.83
					5	129	129	1.64	13.90	0.46	0.76
					6	131	132	4.05	17.95	1.05	0.81
SB-20	9.0	95	LA-4	09-19-90	1	104	105	0.32	0.32	0.09	0.09
					2	114	115	0.64	0.95	0.16	0.13
					3	122	120	0.76	1.71	0.21	0.15
					4	124	123	1.19	2.90	0.31	0.19
					5	126	126	0.65	3.54	0.18	0.19
					6	126	125	1.09	4.63	0.28	0.21
SB-20	9.0	105	NYCC	09-24-90	1	115	115	0.54	0.54	0.46	0.46
					2	122	122	0.96	1.51	0.81	0.63
					3	130	132	1.30	2.81	1.11	0.79
					4	133	134	1.62	4.43	1.37	0.94
					5	135	136	1.94	6.37	1.65	1.08
					6	136	140	3.60	9.97	3.05	1.41
SB-20	7.5	105	NYCC	09-25-90	1	115	115	0.69	0.69	0.58	0.58
					2	122	122	1.00	1.69	0.83	0.71
					3	130	130	1.35	3.04	1.12	0.85
					4	133	133	1.61	4.65	1.36	0.97
					5	135	134	2.30	6.96	1.94	1.16
					6	136	136	1.76	8.72	1.46	1.21

Appendix A
Detailed Running Loss Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	Fuel Temp Target	Fuel Temp Actual	RL - grams Phase	RL - grams Cum	RL - grams/mile Phase	RL - grams/mile Cum
SB-21	9.0	95	LA-4	09-25-90	1	100	98	0.31	0.31	0.09	0.09
					2	109	110	0.45	0.76	0.12	0.10
					3	118	119	0.37	1.13	0.10	0.10
					4	118	123	0.42	1.55	0.11	0.10
					5	119	122	0.23	1.78	0.07	0.10
					6	120	120	0.34	2.12	0.09	0.09
SB-21	9.0	95	LA-4	09-27-90	1	100	98	0.21	0.21	0.06	0.06
					2	109	115	0.58	0.79	0.15	0.11
					3	113	119	0.24	1.03	0.07	0.09
					4	118	120	0.37	1.40	0.10	0.09
					5	119	120	0.24	1.64	0.07	0.09
					6	120	121	0.32	1.96	0.08	0.09
SB-22	9.0	95	LA-4	09-27-90	1	98	98	1.89	1.89	0.51	0.51
					2	105	106	17.90	19.79	4.49	2.58
					3	109	110	15.51	35.30	4.21	3.11
					4	115	115	23.89	59.19	5.93	3.85
					5	117	118	20.09	79.28	5.34	4.14
					6	121	120	20.75	100.03	4.88	4.28
SB-22	9.0	105	NYCC	10-02-90	1	109	108	2.21	2.21	1.92	1.92
					2	113	113	15.46	17.67	13.32	7.63
					3	118	118	24.89	42.56	21.66	12.29
					4	123	123	32.52	75.07	27.94	16.22
					5	126	126	40.30	115.37	34.59	19.92
					6	129	129	43.44	158.81	37.13	22.81
SB-22	7.5	105	NYCC	10-03-90	1	109	109	1.09	1.09	0.92	0.92
					2	113	113	7.44	8.52	6.31	3.62
					3	118	118	14.30	22.82	12.22	6.48
					4	123	123	18.19	41.02	15.39	8.72
					5	126	126	20.39	61.41	17.22	10.43
					6	129	129	19.80	81.21	16.88	11.50
SB-22	7.5	105	LA-4	10-04-90	1	108	108	0.41	0.41	0.12	0.12
					2	115	115	11.09	11.50	2.88	1.55
					3	119	119	8.61	20.11	2.41	1.83
					4	125	125	19.94	40.05	5.17	2.70
					5	127	127	28.15	68.19	7.90	3.71
					6	131	131	1.80	70.00	0.47	3.15
SB-23	9.0	95	LA-4	10-17-90	1	100	99	2.48	2.48	0.69	0.69
					2	107	107	14.96	17.44	3.84	2.33
					3	110	110	11.29	28.73	3.13	2.59
					4	112	113	19.51	48.24	4.96	3.21
					5	114	117	12.95	61.19	3.60	3.29
					6	116	116	8.67	69.86	2.22	3.10

Appendix A
Detailed Running Loss Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	Fuel Temp Target	Fuel Temp Actual	RL - grams Phase	RL - grams Cum	RL - grams/mile Phase	RL - grams/mile Cum
SB-23	7.5	95	NYCC	10-19-90	1	101	100	4.29	4.29	3.57	3.57
					2	107	106	9.38	13.68	7.83	5.69
					3	110	110	10.79	24.46	9.02	6.80
					4	112	112	7.66	32.13	6.48	6.72
					5	114	114	6.87	39.00	5.71	6.52
					6	116	116	7.03	46.03	5.86	6.41
SB-24	9.0	95	LA-4	10-09-90	1	100	100	4.38	4.38	1.21	1.21
					2	108	108	10.34	14.72	2.67	1.96
					3	112	113	6.30	21.02	1.76	1.90
					4	116	116	9.11	30.14	2.35	2.02
					5	118	120	13.50	43.63	3.75	2.35
					6	121	121	6.57	50.20	1.70	2.24
SB-24	9.0	105	NYCC	10-11-90	1	111	112	4.81	4.81	3.79	3.79
					2	118	118	9.09	13.90	7.36	5.55
					3	122	122	11.27	25.17	9.33	6.78
					4	125	125	10.58	35.75	8.58	7.22
					5	128	128	12.33	48.08	10.07	7.79
					6	130	130	14.21	62.29	11.60	8.42
SB-24	7.5	105	NYCC	10-15-90	1	111	111	2.07	2.07	1.72	1.72
					2	118	117	4.05	6.12	3.35	2.54
					3	122	122	4.07	10.19	3.36	2.81
					4	125	125	3.94	14.13	3.25	2.92
					5	128	127	4.58	18.71	3.79	3.09
					6	130	129	4.54	23.26	3.71	3.20
SB-24	7.5	105	LA-4	10-17-90	1	110	110	3.67	3.67	1.02	1.02
					2	118	119	9.57	13.24	2.45	1.77
					3	122	123	4.63	17.86	1.29	1.61
					4	126	125	2.44	20.30	0.63	1.36
					5	128	128	3.09	23.39	0.87	1.26
					6	131	129	1.30	24.70	0.34	1.10
SB-25	9.0	95	LA-4	10-09-90	1	97	97	1.04	1.04	0.29	0.29
					2	101	103	2.48	3.51	0.63	0.47
					3	105	107	2.35	5.86	0.65	0.53
					4	108	111	9.09	14.95	2.34	1.00
					5	111	112	6.55	21.50	1.82	1.16
					6	114	114	10.10	31.60	2.60	1.41
SB-25	9.0	105	NYCC	10-11-90	1	107	108	2.06	2.06	1.70	1.70
					2	111	112	6.59	8.66	5.50	3.59
					3	115	116	17.93	26.59	14.94	7.36
					4	117	120	21.33	47.92	17.55	9.93
					5	121	124	27.62	75.54	22.81	12.51
					6	124	133	36.46	112.00	29.86	15.43

Appendix A
Detailed Running Loss Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	Fuel Temp Target	Fuel Temp Actual	RL - grams Phase	RL - grams Cum	RL - grams/mile Phase	RL - grams/mile Cum
SB-25	7.5	105	NYCC	10-12-90	1	107	107	1.33	1.33	1.12	1.12
					2	111	111	3.63	4.96	3.06	2.09
					3	115	116	7.14	12.11	5.98	3.39
					4	117	120	12.76	24.87	10.71	5.23
					5	121	123	8.47	33.34	7.08	5.60
					6	124	125	7.86	41.20	6.57	5.76
SB-25	9.0	105	NYCC	10-16-90	1	107	106	1.88	1.88	1.57	1.57
					2	111	113	7.10	8.98	6.00	3.78
					3	115	115	18.43	27.41	15.66	7.71
					4	117	118	21.15	48.56	17.90	10.26
					5	121	122	24.78	73.34	20.69	12.36
					6	124	126	27.00	100.34	22.78	14.10
SB-25	7.5	105	LA-4	10-19-90	1	107	107	2.83	2.83	0.78	0.78
					2	111	111	8.69	11.52	2.24	1.54
					3	115	115	4.58	16.10	1.27	1.45
					4	118	120	5.92	22.03	1.52	1.47
					5	121	124	4.12	26.15	1.15	1.41
					6	124	125	6.13	32.28	1.56	1.43
SB-26	9.0	95	LA-4	10-12-90	1	99	99	4.19	4.19	1.17	1.17
					2	104	105	14.46	18.64	3.78	2.52
					3	108	108	8.70	27.34	2.45	2.50
					4	112	114	15.17	42.51	3.95	2.87
					5	114	116	8.14	50.65	2.29	2.76
					6	117	118	19.30	69.95	5.04	3.15
SB-26	9.0	105	NYCC	10-17-90	1	110	108	4.54	4.54	3.75	3.75
					2	114	114	17.52	22.06	14.84	9.22
					3	118	118	18.19	40.25	15.19	11.21
					4	121	121	20.53	60.78	17.28	12.72
					5	124	124	20.59	81.36	17.37	13.64
					6	127	128	24.43	105.80	20.87	14.83
SB-26	9.0	95	NYCC	10-19-90	1	100	100	5.21	5.21	4.35	4.35
					2	104	104	11.75	16.96	9.85	7.09
					3	108	108	11.71	28.67	9.93	8.03
					4	111	111	11.49	40.16	9.62	8.43
					5	114	114	11.32	51.49	9.45	8.63
					6	117	116	11.94	63.43	10.09	8.88
SB-27	9.0	95	LA-4	10-18-90	1	99	97	8.04	8.04	2.24	2.24
					2	106	106	30.80	38.84	7.94	5.20
					3	110	113	14.91	53.75	4.17	4.87
					4	114	115	12.03	65.78	3.11	4.41
					5	116	118	8.50	74.28	2.37	4.01
					6	116	119	11.86	86.14	3.06	3.85

Appendix A
Detailed Running Loss Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	Fuel Temp Target	Fuel Temp Actual	RL - grams Phase	RL - grams Cum	RL - grams/mile Phase	RL - grams/mile Cum
SB-27	9.0	95	NYCC	10-19-90	1	100	99	16.90	16.90	14.01	14.01
					2	106	104	40.27	57.17	33.82	23.85
					3	110	109	50.58	107.76	42.44	30.02
					4	113	113	48.42	156.17	40.86	32.71
					5	116	116	33.17	189.35	27.78	31.73
					6	116	116	19.15	208.50	15.61	28.98
SB-28	9.0	95	LA-4	10-02-90	1	98	98	0.17	0.17	0.05	0.05
					2	109	109	0.19	0.36	0.05	0.05
					3	114	114	0.11	0.47	0.03	0.04
					4	120	120	0.16	0.63	0.04	0.04
					5	122	122	0.11	0.74	0.03	0.04
					6	124	124	0.18	0.92	0.05	0.04
SB-29	9.0	95	LA-4	10-15-90	1	97	101	4.28	4.28	1.18	1.18
					2	101	103	9.56	13.84	2.44	1.84
					3	105	107	6.57	20.41	1.82	1.83
					4	108	110	11.72	32.14	2.99	2.13
					5	111	113	8.61	40.75	2.38	2.18
					6	114	116	10.25	51.00	2.62	2.26
SB-29	9.0	105	NYCC	10-17-90	1	107	110	1.92	1.92	1.56	1.56
					2	111	111	3.36	5.27	2.76	2.15
					3	115	114	8.58	13.86	7.04	3.78
					4	117	119	24.44	38.30	20.07	7.84
					5	121	119	10.81	49.10	8.87	8.04
					6	124	124	23.34	72.45	19.26	9.90
SB-29	9.0	95	NYCC	10-20-90	1	97	98	9.26	9.26	7.88	7.88
					2	101	102	12.45	21.71	10.56	9.22
					3	105	107	11.59	33.30	9.80	9.41
					4	107	111	11.24	44.54	9.54	9.45
					5	111	114	16.86	61.40	14.25	10.41
					6	114	116	17.36	78.76	14.80	11.14
SB-30	9.0	95	LA-4	10-11-90	1	97	100	3.58	3.58	1.00	1.00
					2	101	103	8.25	11.83	2.14	1.59
					3	105	105	4.60	16.43	1.29	1.49
					4	108	108	7.25	23.68	1.88	1.59
					5	111	111	4.09	27.77	1.14	1.50
					6	114	114	10.13	37.90	2.61	1.70
SB-30	9.0	105	NYCC	10-15-90	1	107	107	4.34	4.34	3.63	3.63
					2	111	111	8.93	13.27	7.47	5.55
					3	115	115	12.73	26.00	10.71	7.27
					4	117	117	17.88	43.88	14.97	9.20
					5	121	121	23.25	67.12	19.36	11.24
					6	124	123	24.06	91.18	19.97	12.70

Appendix A
Detailed Running Loss Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	Fuel Temp Target	Fuel Temp Actual	RL - grams Phase	RL - grams Cum	RL - grams/mile Phase	RL - grams/mile Cum
SB-30	9.0	105	LA-4	10-17-90	1	107	112	6.78	6.78	1.88	1.88
					2	111	113	9.62	16.40	2.46	2.18
					3	115	115	5.81	22.20	1.62	2.00
					4	118	117	12.10	34.25	3.11	2.28
					5	121	120	14.47	48.72	4.04	2.62
					6	124	124	28.08	76.80	7.24	3.42
SB-30	7.5	95	NYCC	10-23-90	1	97	97	3.98	3.98	3.37	3.37
					2	101	101	8.85	12.83	7.32	5.37
					3	105	105	11.82	24.65	9.90	6.88
					4	107	108	7.82	32.47	6.56	6.80
					5	111	110	8.97	41.44	7.52	6.94
					6	114	114	16.37	57.81	13.59	8.06
SB-31	9.0	95	LA-4	10-16-90	1	101	100	0.00	0.00	0.00	0.00
					2	113	110	0.26	0.26	0.07	0.03
					3	118	117	0.16	0.42	0.04	0.04
					4	123	123	0.18	0.60	0.05	0.04
					5	124	124	0.16	0.76	0.04	0.04
					6	126	126	0.21	0.97	0.05	0.04
SB-32	9.0	95	LA-4	11-05-90	1	99	98	0.02	0.02	0.01	0.01
					2	107	106	1.33	1.35	0.34	0.18
					3	111	111	4.10	5.46	1.14	0.49
					4	117	117	7.76	13.22	2.01	0.89
					5	119	120	5.81	19.02	1.61	1.03
					6	123	123	3.91	22.94	1.01	1.02
SB-32	7.5	105	NYCC	11-08-90	1	100	98	0.16	0.16	0.11	0.11
					2	107	103	0.24	0.40	0.20	0.15
					3	111	108	0.56	0.96	0.47	0.25
					4	116	113	0.80	1.76	0.68	0.35
					5	118	118	1.04	2.80	0.87	0.45
					6	122	120	0.61	3.41	0.52	0.46
SB-32	7.5	105	NYCC	11-09-90	1	110	107	0.18	0.18	0.15	0.15
					2	117	112	0.31	0.49	0.26	0.21
					3	121	117	1.06	1.55	0.90	0.44
					4	126	120	1.09	2.64	0.93	0.56
					5	128	124	1.24	3.88	1.06	0.66
					6	132	127	1.37	5.25	1.18	0.75
SB-33	9.0	95	LA-4	10-22-90	1	99	99	1.42	1.42	0.40	0.40
					2	109	109	4.07	5.49	1.05	0.73
					3	115	115	3.28	8.78	0.91	0.79
					4	121	121	5.42	14.19	1.40	0.95
					5	123	125	4.58	18.78	1.28	1.01
					6	125	127	6.75	25.52	1.75	1.14

Appendix A
Detailed Running Loss Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	Fuel Temp Target	Fuel Temp Actual	RL - grams Phase	RL - grams Cum	RL - grams/mile Phase	RL - grams/mile Cum
SB-33	9.0	95	NYCC	11-01-90	1	99	98	2.14	2.14	1.81	1.81
					2	109	106	4.64	6.78	3.91	2.86
					3	115	114	6.03	12.81	5.01	3.59
					4	121	120	6.09	18.91	5.03	3.95
					5	123	126	6.96	25.87	5.74	4.31
					6	125	125	5.30	31.18	4.42	4.33
SB-33	7.5	95	NYCC	11-02-90	1	100	99	0.57	0.57	0.50	0.50
					2	108	105	3.49	4.06	3.02	1.77
					3	114	111	5.31	9.37	4.59	2.71
					4	119	119	5.68	15.05	4.95	3.27
					5	122	121	6.07	21.12	5.28	3.67
					6	124	124	5.81	26.94	5.03	3.90
SB-34	9.0	95	LA-4	10-31-90	1	100	98	1.36	1.36	0.32	0.32
					2	106	105	1.51	2.87	0.39	0.35
					3	110	110	0.99	3.86	0.27	0.33
					4	114	114	1.17	5.03	0.30	0.32
					5	116	116	0.75	5.78	0.21	0.30
					6	118	118	0.86	6.64	0.21	0.29
SB-35	9.0	95	LA-4	11-26-90	1	105	104	0.40	0.40	0.11	0.11
					2	116	115	0.82	1.21	0.21	0.16
					3	122	122	0.71	1.93	0.20	0.17
					4	127	127	0.88	2.80	0.22	0.19
					5	129	129	0.66	3.46	0.18	0.19
					6	133	132	0.85	4.31	0.22	0.19
SB-35	9.0	105	LA-4	11-30-90	1	115	113	0.44	0.44	0.12	0.12
					2	126	126	1.53	1.97	0.39	0.26
					3	132	132	1.17	3.14	0.32	0.28
					4	137	137	20.00	23.14	5.15	1.54
					5	139	139	22.56	45.71	6.22	2.44
					6	143	142	46.09	91.80	11.68	4.05
SB-35	7.5	95	NYCC	12-03-90	1	105	105	5.30	5.30	4.40	4.40
					2	116	114	11.75	17.05	9.55	7.00
					3	122	121	15.78	32.82	12.92	8.98
					4	127	126	18.15	50.97	14.86	10.45
					5	129	129	19.50	70.47	16.10	11.58
					6	133	132	26.84	97.30	21.92	13.31
SB-35	9.0	105	NYCC	12-04-90	1	116	113	0.50	0.50	0.42	0.42
					2	124	121	0.87	1.36	0.72	0.57
					3	131	130	1.07	2.43	0.89	0.68
					4	135	132	17.78	20.21	14.80	4.21
					5	138	135	27.04	47.25	22.57	7.88
					6	141	138	38.58	85.83	32.15	11.93

Appendix B
Detailed Exhaust Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	Exhaust Emissions (grams/mile) NOx	HC	CO2	CO	MPG
ARB-1	9.0	95	LA-4	09-20-89	1	1.97	2.77	486.6	45.18	15.68
					2	0.72	0.92	538.2	10.06	15.95
					3	1.30	0.83	478.8	9.15	17.92
					4	0.69	0.77	528.4	10.82	16.21
					5	1.22	0.68	479.9	8.57	17.93
					6	0.67	0.75	531.3	9.91	16.17
ARB-1	9.0	95	LA-4	09-21-89	1	2.19	2.63	504.9	38.13	15.50
					2	0.77	1.01	557.3	10.35	15.40
					3	1.46	0.93	487.9	9.35	17.57
					4	0.73	0.86	551.6	10.24	15.57
					5	1.36	0.94	486.0	8.44	17.68
					6	0.70	0.85	549.4	7.93	15.73
ARB-2	9.0	95	LA-4	09-15-89	1	1.23	0.63	317.3	17.59	25.60
					2	1.42	0.15	327.3	6.59	26.27
					3	1.43	0.19	298.1	7.27	28.64
					4	1.58	0.14	324.8	6.11	26.53
					5	1.25	0.13	299.4	5.02	28.87
					6	1.59	0.12	321.1	5.21	26.94
ARB-2	9.0	105	LA-4	09-22-89	1	1.00	0.70	331.1	18.72	24.49
					2	1.40	0.17	350.6	7.37	24.49
					3	1.10	0.19	303.9	8.10	28.00
					4	1.37	0.14	329.2	7.22	26.05
					5	1.28	0.14	311.1	5.94	27.68
					6	1.55	0.12	326.7	5.72	26.43
ARB-2	9.0	95	NYCC	09-23-89	1	2.24	1.51	610.6	23.98	13.60
					2	2.18	0.49	554.5	15.07	15.32
					3	2.40	0.52	548.5	17.24	15.39
					4	2.25	0.52	548.5	16.96	15.40
					5	2.10	0.47	563.1	15.29	15.09
					6	2.10	0.56	556.8	14.20	15.29
ARB-2	7.5	95	LA-4	09-26-89	1	0.92	0.56	330.5	17.99	24.64
					2	0.98	0.12	337.1	4.55	25.77
					3	0.99	0.15	309.6	5.64	27.85
					4	1.17	0.11	344.2	4.99	25.20
					5	1.02	0.14	313.7	5.32	27.55
					6	1.15	0.09	338.3	4.34	25.71
ARB-3	9.0	95	LA-4	09-18-89	1	1.04	0.75	507.2	12.15	16.80
					2	0.37	0.46	515.7	9.86	16.68
					3	2.18	0.61	426.2	8.04	20.15
					4	1.44	0.57	477.9	4.73	18.23
					5	1.30	0.49	444.7	7.52	19.39
					6	0.28	0.86	517.7	13.06	16.42

Appendix B
Detailed Exhaust Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	NOx	HC	CO2	CO	MPG
						Exhaust Emissions (grams/mile)				
ARB-4	9.0	95	LA-4	09-14-89	1	1.72	1.64	340.0	15.13	24.08
					2	1.20	0.64	424.5	1.94	20.68
					3	1.17	0.63	327.8	5.43	26.25
					4	1.27	0.65	401.6	2.87	21.76
					5	1.43	0.96	304.5	13.29	27.04
					6	1.27	0.53	411.6	0.93	21.41
ARB-4	9.0	95	LA-4	09-21-89	1	1.28	1.71	345.7	23.63	22.88
					2	1.03	0.57	432.7	1.38	20.34
					3	1.08	0.61	328.1	7.53	25.98
					4	1.16	0.49	415.7	0.84	21.22
					5	1.24	0.71	319.9	9.76	26.32
					6	1.15	0.49	408.9	0.89	21.57
ARB-5	9.0	95	LA-4	09-20-89	1	2.11	1.01	452.7	37.07	17.27
					2	0.77	0.62	414.3	34.81	18.86
					3	1.52	0.36	419.9	11.53	20.22
					4	0.90	0.36	420.9	14.90	19.94
					5	1.78	0.31	419.9	5.35	20.69
					6	1.02	0.32	423.5	7.10	20.39
ARB-5	9.0	105	NYCC	09-22-89	1	4.39	3.33	760.3	98.54	9.60
					2	2.18	1.10	738.7	56.15	10.70
					3	2.11	1.35	716.5	70.28	10.69
					4	2.23	1.50	712.8	75.03	10.63
					5	2.27	1.30	715.5	67.31	10.76
					6	2.45	1.21	721.0	62.70	1.78
ARB-5	7.5	95	LA-4	09-26-89	1	2.43	1.09	458.8	29.90	17.44
					2	1.24	0.43	449.6	5.08	19.35
					3	2.33	0.40	431.0	3.36	20.30
					4	1.68	0.47	439.4	1.57	20.04
					5	2.55	0.38	425.0	2.37	20.66
					6	1.74	0.45	435.8	1.04	20.24
ARB-5	9.0	95	NYCC	09-27-89	1	3.53	3.32	863.9	87.91	8.77
					2	2.06	0.87	823.8	15.61	10.44
					3	2.14	0.83	790.4	11.24	10.96
					4	2.29	0.81	804.9	11.06	10.77
					5	2.52	1.13	797.0	11.25	10.86
					6	2.69	0.85	806.1	4.34	10.89
ARB-6	9.0	95	LA-4	09-21-89	1	1.72	0.94	540.8	17.13	15.56
					2	1.13	0.37	599.5	0.25	14.78
					3	3.42	0.28	518.9	0.46	17.06
					4	1.16	0.39	583.9	0.29	15.17
					5	3.21	0.30	507.6	0.51	17.44
					6	0.95	0.37	597.2	0.41	14.83

Appendix B
Detailed Exhaust Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	Exhaust Emissions (grams/mile) NOx	HC	CO2	CO	MPG
ARB-6	9.0	95	LA-4	09-22-89	1	3.92	0.71	550.0	10.33	15.62
					2	1.04	0.38	599.5	0.37	14.77
					3	2.79	0.28	513.2	0.81	17.24
					4	0.91	0.35	588.3	0.59	15.05
					5	2.95	0.28	510.7	0.69	17.33
					6	1.12	0.38	572.5	0.40	15.47
SB-1	9.0	95	LA-4	10-17-89	1	1.48	1.27	560.7	16.89	15.02
					2	0.58	0.36	618.0	1.01	14.31
					3	1.19	0.31	526.1	1.95	16.76
					4	0.44	0.42	596.6	7.57	14.57
					5	0.71	0.77	506.7	14.09	16.72
					6	0.33	0.56	593.7	12.46	14.44
SB-2	9.0	95	LA-4	10-05-89	1	0.46	0.68	308.7	16.92	26.32
					2	0.33	0.21	330.9	5.34	26.13
					3	0.30	0.15	277.9	7.01	30.70
					4	0.33	0.15	321.4	6.57	26.74
					5	0.36	0.13	267.5	9.72	31.37
					6	0.49	0.23	322.4	3.49	27.03
SB-3	9.0	95	LA-4	10-17-89	1	1.71	1.57	457.3	19.34	18.03
					2	0.90	0.44	477.0	0.94	18.51
					3	1.61	0.33	429.3	1.49	20.53
					4	0.99	0.50	473.0	2.62	18.56
					5	1.83	0.35	428.0	2.16	20.54
					6	1.07	0.47	469.2	1.41	18.79
SB-4	9.0	95	LA-4	10-06-89	1	1.54	1.29	350.7	31.24	21.99
					2	1.62	0.45	398.6	0.96	22.12
					3	1.88	0.52	345.4	5.77	24.94
					4	1.80	0.45	394.3	1.61	22.30
					5	1.85	0.43	344.7	5.13	25.09
					6	1.83	0.45	399.3	1.95	22.00
SB-5	9.0	95	LA-4	10-27-89	1	2.59	1.06	391.6	32.87	19.89
					2	0.85	0.29	416.3	15.89	20.09
					3	2.26	0.36	388.3	14.17	21.58
					4	1.07	0.21	428.7	10.17	19.95
					5	2.38	0.36	387.9	14.28	21.59
					6	1.03	0.23	431.7	11.94	19.69
SB-6	9.0	95	LA-4	03-06-90	1	0.69	0.44	369.5	4.11	23.54
					2	0.10	0.02	415.5	0.86	21.31
					3	0.16	0.03	330.4	1.26	26.72
					4	0.11	0.02	402.6	0.82	21.99
					5	0.15	0.03	325.2	1.18	27.15
					6	0.13	0.02	393.0	0.66	22.54

Appendix B
Detailed Exhaust Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	NOx	HC	CO2	CO	MPG
SB-6	9.0	95	LA-4	03-08-90	1	0.73	0.36	350.1	4.12	24.83
					2	0.28	1.53	366.8	28.66	21.32
					3	0.18	0.07	322.9	1.60	27.28
					4	0.12	0.02	388.5	0.91	22.77
					5	0.18	0.03	321.1	1.17	27.49
					6	0.14	0.02	387.1	0.81	22.87
SB-6	9.0	105	LA-4	03-16-90	1	0.44	0.32	326.7	3.71	26.63
					2	0.16	0.04	381.1	2.28	23.08
					3	0.19	0.05	314.2	2.34	27.93
					4	0.18	0.04	375.5	2.64	23.39
					5	0.28	0.05	316.8	2.19	27.73
					6	0.19	0.05	377.3	2.40	23.30
SB-7	9.0	95	LA-4	03-15-90	1	0.90	0.35	342.4	7.47	25.00
					2	0.63	0.03	361.8	0.66	24.47
					3	0.67	0.05	317.0	1.90	27.74
					4	0.99	0.06	350.0	3.51	24.97
					5	0.88	0.09	309.7	5.08	27.94
					6	1.05	0.06	346.2	3.64	25.23
SB-7	9.0	105	LA-4	03-19-90	1	0.92	0.30	326.6	5.06	26.48
					2	0.81	0.03	358.2	0.78	24.71
					3	0.80	0.05	314.5	2.84	27.83
					4	0.99	0.06	347.8	3.38	25.14
					5	0.92	0.09	310.7	4.95	27.87
					6	1.26	0.08	349.5	5.10	24.83
SB-8	9.0	95	LA-4	04-04-90	1	1.19	0.79	372.9	4.04	23.27
					2	0.48	0.02	437.6	0.03	20.29
					3	0.22	0.04	366.6	0.75	24.14
					4	0.74	0.03	443.3	0.04	20.03
					5	0.44	0.02	365.6	0.14	24.28
					6	0.64	0.02	442.9	0.04	20.05
SB-10	9.0	95	LA-4	08-29-90	1	5.34	4.16	532.9	6.38	15.97
					2	4.16	3.56	557.8	2.15	15.52
					3	5.58	2.63	491.0	7.32	17.39
					4	4.23	4.24	549.2	3.55	15.63
					5	5.90	2.99	484.2	7.93	17.55
					6	4.61	4.12	550.7	3.47	15.60
SB-10	9.0	105	NYCC	08-31-90	1	5.76	21.83	1052.3	35.14	7.55
					2	5.85	13.02	1052.5	31.68	7.77
					3	5.46	12.79	1023.9	30.49	7.99
					4	5.90	13.21	1019.6	23.46	8.09
					5	6.34	13.34	1035.9	23.86	7.96
					6	5.69	13.40	1013.1	28.87	8.07

Exhaust Emissions (grams/mile) apply to columns NOx, HC, CO2, CO.

Appendix B
Detailed Exhaust Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	NOx	HC	CO2	CO	MPG
						Exhaust Emissions (grams/mile)				
SB-10	9.0	95	LA-4	09-07-90	1	6.65	5.19	530.4	7.51	15.90
					2	4.68	3.85	560.4	1.93	15.43
					3	7.21	2.67	493.1	5.57	17.40
					4	4.28	4.31	547.5	2.93	15.70
					5	6.98	2.97	490.5	5.28	17.48
					6	4.35	4.52	545.1	2.11	15.78
SB-10	9.0	95	NYCC	09-10-90	1	6.78	18.63	1165.9	14.30	7.12
					2	7.45	11.27	1103.9	5.56	7.73
					3	7.36	10.80	1082.9	7.44	7.87
					4	7.00	11.25	1067.8	7.79	7.96
					5	6.84	11.79	1049.7	9.98	8.05
					6	6.27	11.70	1056.8	18.59	7.91
SB-10	7.5	95	LA-4	09-12-90	1	6.34	1.33	540.3	8.64	15.92
					2	4.17	3.59	563.8	1.48	15.38
					3	6.83	2.67	496.6	3.39	17.40
					4	4.41	3.80	556.7	1.18	15.57
					5	7.05	2.51	514.5	3.88	16.81
					6	4.08	3.71	550.7	1.10	15.74
SB-11	9.0	95	LA-4	08-30-90	1	2.63	2.01	402.1	18.52	20.30
					2	1.65	1.04	500.0	14.61	16.88
					3	2.34	1.26	390.1	15.46	21.23
					4	1.74	1.33	503.4	10.44	16.95
					5	2.37	1.29	383.6	15.64	21.55
					6	1.86	1.38	497.2	11.96	17.07
SB-12	9.0	95	LA-4	09-10-90	1	6.15	3.83	542.8	20.48	15.13
					2	3.41	3.91	535.7	32.10	14.84
					3	5.29	3.67	488.3	32.29	16.13
					4	3.71	3.71	530.3	27.86	15.16
					5	5.64	3.44	494.6	22.92	16.40
					6	3.42	3.96	533.4	24.98	15.18
SB-12	9.0	95	NYCC	09-12-90	1	5.15	8.81	1034.4	73.55	7.54
					2	5.00	8.63	987.1	81.94	7.77
					3	5.06	8.63	967.9	84.79	7.87
					4	4.60	8.70	950.6	89.55	7.94
					5	4.61	8.71	942.9	91.80	7.97
					6	4.78	9.17	937.4	93.19	7.98
SB-12	7.5	95	LA-4	09-13-90	1	4.67	4.95	529.9	20.14	15.39
					2	2.94	3.92	531.6	31.00	14.99
					3	5.04	3.80	484.7	28.73	16.39
					4	3.33	3.73	523.3	32.52	15.15
					5	5.26	3.52	487.2	27.29	16.41
					6	3.26	3.61	515.4	32.05	15.39

Appendix B
Detailed Exhaust Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	Exhaust Emissions (grams/mile) NOx	HC	CO2	CO	MPG
SB-12	9.0	105	NYCC	09-14-90	1	4.41	9.11	970.2	83.15	7.86
					2	4.38	8.30	924.8	94.31	8.08
					3	4.13	9.30	898.3	126.28	7.89
					4	4.11	9.59	885.8	138.02	7.84
					5	3.85	9.42	883.1	142.21	7.82
					6	4.00	9.48	874.1	140.64	7.89
SB-12	9.0	105	LA-4	09-18-90	1	5.67	4.09	575.7	34.12	13.83
					2	4.59	4.31	585.1	48.17	13.17
					3	4.97	4.46	527.9	64.75	13.80
					4	4.06	4.85	559.9	71.69	12.91
					5	5.36	4.55	524.0	64.17	13.89
					6	4.08	4.84	560.2	71.54	12.91
SB-12	9.0	80	LA-4	09-19-90	1	4.97	4.19	592.9	42.80	13.19
					2	4.35	4.08	589.8	37.33	13.43
					3	4.85	4.13	540.3	45.85	14.20
					4	4.71	4.04	587.7	35.36	13.54
					5	4.92	4.26	542.3	50.00	14.00
					6	4.77	4.03	583.9	34.39	13.65
SB-13	9.0	95	LA-4	09-27-90	1	1.55	1.22	685.8	51.26	11.53
					2	1.41	0.95	780.6	48.08	10.34
					3	1.90	0.67	649.4	41.15	12.40
					4	1.70	1.34	767.2	46.34	10.52
					5	1.92	0.98	645.4	43.04	12.40
					6	1.70	1.89	775.7	51.35	10.30
SB-14	9.0	95	LA-4	09-05-90	1	1.52	2.01	512.7	14.63	16.39
					2	0.47	0.33	534.7	0.23	16.57
					3	0.88	0.30	484.9	0.82	18.24
					4	0.51	0.32	525.2	0.41	16.86
					5	0.97	0.35	483.6	0.48	18.30
					6	0.56	0.36	524.2	0.41	16.89
SB-15	9.0	95	LA-4	09-17-90	1	0.94	0.79	323.5	5.77	26.51
					2	0.10	0.06	309.2	1.92	28.43
					3	0.14	0.12	289.5	2.47	30.23
					4	0.12	0.06	302.7	2.22	29.00
					5	0.13	0.11	285.7	2.61	30.61
					6	0.19	0.05	303.7	2.06	28.92
SB-16	9.0	95	LA-4	09-24-90	1	1.20	3.37	435.2	101.80	14.66
					2	1.26	2.71	466.1	58.73	15.67
					3	1.03	2.93	389.7	95.16	16.19
					4	1.27	2.79	461.7	58.48	15.79
					5	0.96	3.01	380.5	98.77	16.29
					6	1.13	2.89	451.1	65.45	15.77

Appendix B
Detailed Exhaust Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	NOx	HC	CO2	CO	MPG
						Exhaust Emissions (grams/mile)				
SB-16	9.0	105	NYCC	09-28-90	1	1.90	7.72	979.3	164.35	7.04
					2	2.19	5.72	893.1	122.05	8.05
					3	2.01	6.02	870.4	124.36	8.19
					4	1.97	6.18	866.5	126.89	8.18
					5	2.15	6.46	863.9	123.85	8.23
					6	1.88	6.23	872.3	131.92	8.08
SB-16	9.0	105	LA-4	10-01-90	1	1.21	3.70	472.5	123.19	13.10
					2	1.17	2.74	500.9	72.52	14.24
					3	1.03	2.76	383.0	97.17	16.31
					4	1.21	2.82	443.9	68.44	15.85
					5	1.04	3.17	427.3	119.77	14.20
					6	1.17	2.80	457.9	72.83	15.28
SB-16	7.5	105	NYCC	10-02-90	1	1.76	6.33	897.0	139.87	7.81
					2	2.14	5.35	871.3	110.67	8.36
					3	2.25	5.55	871.2	117.86	8.27
					4	2.10	5.35	891.4	127.98	8.01
					5	2.03	5.49	880.9	143.71	7.90
					6	2.12	5.48	889.0	133.74	7.96
SB-17	9.0	95	LA-4	10-01-90	1	0.90	0.94	402.0	21.42	20.25
					2	0.75	0.21	405.8	1.29	21.75
					3	0.86	0.18	340.7	3.53	25.61
					4	1.03	0.16	388.8	0.33	22.79
					5	1.36	0.15	335.3	0.83	26.35
					6	1.11	0.20	381.3	0.40	23.22
SB-17	9.0	105	NYCC	10-04-90	1	2.13	2.56	879.6	29.64	9.51
					2	1.36	0.58	744.4	5.00	11.78
					3	1.83	0.44	732.6	2.16	12.05
					4	1.89	0.58	720.6	2.29	12.23
					5	1.95	0.59	721.1	2.41	12.22
					6	2.22	0.47	731.4	1.65	12.08
SB-17	7.5	105	NYCC	10-05-90	1	2.37	2.16	871.2	21.42	9.74
					2	1.68	0.55	728.5	3.31	12.08
					3	1.83	0.48	697.3	2.98	12.63
					4	1.94	0.44	694.6	1.85	12.71
					5	2.04	0.42	685.8	2.16	12.86
					6	2.03	0.46	690.7	1.28	12.80
SB-17	7.5	105	LA-4	10-10-90	1	1.01	0.92	343.7	18.14	23.68
					2	0.88	0.21	362.7	1.20	24.32
					3	1.11	0.15	303.7	1.50	28.98
					4	1.16	0.16	341.0	0.34	25.97
					5	1.41	0.15	303.5	1.16	29.05
					6	1.30	0.16	345.6	0.20	25.64

Appendix B
Detailed Exhaust Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	NOx	HC	CO2	CO	MPG
						Exhaust Emissions (grams/mile)				
SB-18	9.0	95	LA-4	09-17-90	1	1.18	0.72	321.4	5.03	26.79
					2	0.36	0.03	383.4	0.52	23.11
					3	0.53	0.03	260.3	0.51	34.00
					4	0.33	0.03	377.3	0.50	23.49
					5	0.70	0.04	316.1	0.74	27.99
					6	0.40	0.03	380.0	0.35	23.34
SB-18	9.0	105	NYCC	09-19-90	1	2.07	2.20	745.3	20.56	11.32
					2	1.60	0.23	738.8	10.18	11.76
					3	1.30	0.57	719.5	23.19	11.72
					4	1.79	0.51	719.5	20.98	11.78
					5	1.40	0.95	723.0	30.12	11.49
					6	1.61	0.83	716.7	22.05	11.78
SB-18	7.5	105	NYCC	09-24-90	1	1.82	1.99	635.1	16.06	13.32
					2	0.96	0.25	620.4	6.73	14.06
					3	0.82	0.28	614.9	8.40	14.12
					4	0.78	0.26	608.9	8.37	14.26
					5	0.81	0.41	619.8	13.11	13.84
					6	1.14	0.28	666.6	8.09	13.06
SB-18	9.0	105	LA-4	09-27-90	1	0.88	0.51	315.3	2.51	27.69
					2	0.43	0.03	377.1	0.22	23.53
					3	0.68	0.03	305.3	0.50	29.01
					4	0.35	0.03	372.8	0.54	23.77
					5	0.67	0.04	306.9	0.88	28.81
					6	0.38	0.03	372.5	0.50	23.79
SB-18	9.0	105	LA-4	09-28-90	1	0.95	0.57	325.8	4.06	26.59
					2	0.25	0.03	377.1	0.40	23.51
					3	0.56	0.06	306.2	2.53	28.62
					4	0.29	0.03	372.9	0.68	23.75
					5	0.59	0.04	307.4	1.14	28.71
					6	0.30	0.02	372.0	1.03	23.77
SB-19	9.0	95	LA-4	09-13-90	1	1.78	1.37	511.4	19.97	16.24
					2	0.89	0.47	522.2	2.19	16.85
					3	1.52	0.33	491.5	0.96	17.98
					4	0.96	0.37	515.3	0.71	17.16
					5	1.50	0.34	483.2	1.20	18.27
					6	1.05	0.44	508.6	1.16	17.36
SB-19	9.0	105	NYCC	09-18-90	1	3.17	3.69	1207.4	32.74	6.99
					2	3.31	1.17	1150.7	5.69	7.64
					3	3.63	1.18	1139.4	4.75	7.72
					4	3.01	2.71	1176.2	34.61	7.17
					5	3.17	2.16	1116.6	31.60	7.57
					6	4.53	2.27	1169.7	26.73	7.29

Appendix B
Detailed Exhaust Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	NOx	HC	CO2	CO	MPG
						Exhaust Emissions (grams/mile)				
SB-19	9.0	95	NYCC	09-19-90	1	1.90	4.33	1038.5	39.36	7.97
					2	1.72	1.30	1054.5	11.07	8.25
					3	2.06	0.96	1057.7	4.19	8.32
					4	2.01	1.04	1059.4	4.05	8.31
					5	1.84	1.00	980.0	4.62	8.97
					6	1.83	0.93	972.2	2.95	9.07
SB-19	9.0	95	LA-4	09-20-90	1	1.24	1.13	489.8	16.75	17.09
					2	0.98	0.32	532.1	0.35	16.64
					3	1.20	0.29	455.1	0.42	19.45
					4	1.17	0.38	521.1	0.47	16.98
					5	1.55	0.38	459.3	1.81	19.17
					6	1.17	0.42	518.2	0.68	17.06
SB-19	7.5	105	NYCC	09-24-90	1	2.30	3.48	1047.9	19.70	8.15
					2	2.00	0.72	968.0	0.96	9.14
					3	1.83	0.77	849.3	1.55	10.40
					4	2.22	0.92	931.5	1.27	9.49
					5	2.16	1.02	947.6	1.62	9.32
					6	2.15	1.15	912.7	1.02	9.68
SB-19	7.5	105	LA-4	09-27-90	1	1.46	1.26	490.4	15.25	17.14
					2	1.42	0.36	640.7	0.49	13.82
					3	2.21	0.33	550.2	3.88	15.94
					4	1.51	0.35	625.6	0.53	14.16
					5	2.47	0.30	539.6	2.02	16.34
					6	1.69	0.34	625.7	0.57	14.15
SB-20	9.0	95	LA-4	09-19-90	1	1.01	0.58	500.7	9.45	17.17
					2	1.31	0.02	540.6	0.21	16.42
					3	1.05	0.03	453.4	0.41	19.56
					4	1.45	0.02	543.4	0.41	16.33
					5	0.98	0.02	455.3	0.37	19.48
					6	1.58	0.02	539.7	0.35	16.44
SB-20	9.0	105	NYCC	09-24-90	1	1.97	1.55	884.4	20.30	9.64
					2	2.41	0.11	857.0	2.54	10.31
					3	2.56	0.23	841.1	9.68	10.36
					4	2.45	0.34	852.7	11.43	10.19
					5	2.55	0.18	842.3	5.24	10.44
					6	2.43	0.24	840.5	6.83	10.43
SB-20	7.5	105	NYCC	09-25-90	1	1.97	2.13	875.3	24.11	9.66
					2	1.95	0.10	840.7	2.22	10.52
					3	2.12	0.11	841.2	2.92	10.50
					4	2.28	0.10	831.3	2.52	10.63
					5	2.27	0.11	849.5	2.81	10.40
					6	1.85	0.06	825.6	0.70	10.74

Appendix B
Detailed Exhaust Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	NOx	HC	CO2	CO	MPG
						Exhaust Emissions (grams/mile)				
SB-21	9.0	95	LA-4	09-25-90	1	1.57	0.63	394.7	7.67	21.73
					2	0.78	0.10	455.3	3.11	19.29
					3	0.76	0.10	383.9	3.33	22.81
					4	0.83	0.12	445.0	3.07	19.73
					5	0.86	0.13	371.7	3.19	23.55
					6	0.79	0.12	366.8	3.45	23.84
SB-21	9.0	95	LA-4	09-27-90	1	1.67	0.62	425.8	9.23	20.09
					2	0.78	0.11	464.1	2.89	18.94
					3	0.75	0.12	371.2	2.66	23.64
					4	0.86	0.13	443.0	3.05	19.82
					5	0.79	0.12	368.0	2.96	23.81
					6	0.88	0.13	441.4	2.76	19.91
SB-22	9.0	95	LA-4	09-27-90	1	1.09	1.13	409.2	6.91	20.97
					2	0.40	0.22	462.1	3.92	18.94
					3	0.65	0.23	378.0	2.68	23.20
					4	0.37	0.19	439.7	2.75	19.98
					5	0.58	0.29	361.2	3.03	24.21
					6	0.40	0.22	433.4	3.07	20.24
SB-22	9.0	105	NYCC	10-02-90	1	1.90	3.62	808.4	19.66	10.44
					2	0.88	0.88	756.0	8.33	11.51
					3	0.95	0.79	773.6	8.80	11.25
					4	0.86	0.62	755.5	7.84	11.54
					5	0.76	0.80	738.7	7.28	11.80
					6	0.78	0.78	750.3	7.13	11.63
SB-22	7.5	105	NYCC	10-03-90	1	1.89	4.01	840.0	24.00	9.98
					2	0.85	0.88	803.5	9.50	10.82
					3	0.87	0.68	784.3	10.10	11.07
					4	0.84	0.73	804.5	8.65	10.83
					5	0.96	0.82	819.9	10.01	10.60
					6	1.13	1.12	842.9	13.83	10.23
SB-22	7.5	105	LA-4	10-04-90	1	1.30	1.07	432.2	7.45	19.86
					2	0.50	0.17	486.1	2.72	18.09
					3	0.74	0.22	405.2	3.80	21.56
					4	0.57	0.19	488.7	2.71	18.00
					5	0.82	0.26	402.0	3.56	21.75
					6	0.52	0.20	479.5	2.68	18.34
SB-23	9.0	95	LA-4	10-17-90	1	8.24	2.23	438.8	32.00	17.90
					2	6.56	2.29	411.9	42.43	18.28
					3	9.19	1.56	391.7	23.59	20.48
					4	6.31	2.58	395.8	51.95	18.29
					5	8.96	1.67	389.0	25.46	20.45
					6	7.00	2.44	395.7	46.29	18.65

Appendix B
Detailed Exhaust Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	NOx	HC	CO2	CO	MPG
						Exhaust Emissions (grams/mile)				
SB-23	7.5	95	NYCC	10-19-90	1	9.47	7.02	798.5	119.45	8.81
					2	10.22	4.57	763.9	84.45	9.75
					3	9.17	4.55	748.6	82.72	9.95
					4	11.17	4.38	775.6	70.97	9.86
					5	10.70	4.29	760.7	68.93	10.06
					6	10.91	4.37	761.7	69.03	10.05
SB-24	9.0	95	LA-4	10-09-90	1	1.44	2.47	278.0	63.58	23.02
					2	1.01	2.42	271.9	69.46	22.85
					3	1.18	2.16	241.2	68.67	24.95
					4	1.00	2.50	258.7	73.25	23.27
					5	1.23	2.06	241.4	64.89	25.39
					6	0.99	2.46	256.4	71.39	23.60
SB-24	9.0	105	NYCC	10-11-90	1	1.93	9.11	503.9	155.30	11.43
					2	1.33	5.18	462.1	159.98	12.17
					3	1.18	5.36	446.0	175.75	12.02
					4	1.37	4.87	457.5	150.37	12.52
					5	1.29	4.80	461.7	147.98	12.52
					6	1.38	4.81	450.9	148.46	12.70
SB-24	7.5	105	NYCC	10-15-90	1	2.16	6.56	508.4	138.18	11.90
					2	1.73	4.63	497.4	129.64	12.41
					3	1.71	4.69	473.0	142.08	12.49
					4	1.64	4.60	479.6	137.66	12.50
					5	1.73	4.73	466.0	140.95	12.64
					6	1.73	4.43	492.1	124.50	12.66
SB-24	7.5	105	LA-4	10-17-90	1	1.70	2.99	275.9	78.68	21.72
					2	1.22	2.62	276.7	79.66	21.65
					3	1.70	2.26	258.5	75.30	23.13
					4	1.27	2.77	267.6	88.04	21.42
					5	1.76	2.32	252.3	77.35	23.30
					6	1.37	2.77	268.6	87.43	21.42
SB-25	9.0	95	LA-4	10-09-90	1	2.43	2.76	715.0	68.78	10.68
					2	2.05	2.16	810.0	51.48	9.89
					3	3.04	2.24	660.5	55.92	11.76
					4	2.56	2.21	821.5	54.72	9.71
					5	2.97	2.24	637.7	55.80	12.13
					6	2.32	2.35	788.6	50.56	10.15
SB-25	9.0	105	NYCC	10-11-90	1	4.53	7.75	1686.9	106.62	4.73
					2	4.39	4.57	1604.5	110.02	4.96
					3	4.55	4.72	1565.1	132.77	4.97
					4	4.46	4.91	1555.9	153.81	4.90
					5	4.42	5.06	1532.0	174.48	4.87
					6	4.56	5.13	1513.7	196.75	4.83

Appendix B
Detailed Exhaust Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	NOx	HC	CO2	CO	MPG
						Exhaust Emissions (grams/mile)				
SB-25	7.5	105	NYCC	10-12-90	1	4.49	8.28	1671.9	104.96	4.77
					2	4.77	4.39	1608.9	119.32	4.91
					3	4.76	3.85	1593.6	121.70	4.94
					4	4.92	3.90	1603.2	113.20	4.95
					5	4.71	3.96	1579.3	113.53	5.02
					6	5.21	3.95	1573.3	110.59	5.05
SB-25	9.0	105	NYCC	10-16-90	1	5.29	8.40	1694.5	105.57	4.71
					2	5.52	3.98	1657.7	101.01	4.86
					3	5.75	4.25	1640.8	146.17	4.71
					4	5.71	4.43	1617.7	168.82	4.68
					5	6.02	4.88	1584.0	179.00	4.72
					6	7.09	5.37	1650.0	196.42	4.50
SB-25	7.5	105	LA-4	10-19-90	1	3.76	3.02	710.8	72.77	10.64
					2	3.29	2.10	815.7	60.96	9.67
					3	4.27	2.30	651.8	81.75	11.28
					4	3.50	2.31	791.8	82.82	9.56
					5	4.72	2.54	653.7	94.25	10.97
					6	3.96	2.53	785.9	95.24	9.41
SB-26	9.0	95	LA-4	10-12-90	1	-	-	-	-	-
					2	4.05	5.72	391.2	120.60	14.83
					3	2.98	4.82	361.3	89.15	17.19
					4	1.47	5.87	372.7	123.61	15.17
					5	3.12	4.88	360.0	86.67	17.36
					6	1.67	5.75	382.6	119.89	15.07
SB-26	9.0	105	NYCC	10-17-90	1	3.93	12.91	721.0	258.10	7.61
					2	3.32	12.21	698.7	285.22	7.49
					3	3.18	12.10	670.2	286.99	7.66
					4	3.03	13.47	665.1	305.05	7.48
					5	3.17	13.05	672.5	301.58	7.48
					6	3.09	12.74	674.7	297.45	7.51
SB-26	9.0	95	NYCC	10-19-90	1	4.17	11.34	755.2	234.75	7.66
					2	2.99	11.37	705.6	276.60	7.55
					3	2.90	11.71	696.2	277.44	7.60
					4	2.95	11.35	699.9	274.34	7.61
					5	2.68	11.31	686.3	273.47	7.71
					6	2.77	11.29	692.3	273.34	7.67
SB-27	9.0	95	LA-4	10-18-90	1	3.77	6.22	488.3	81.08	13.98
					2	1.59	6.35	460.4	107.52	13.68
					3	2.48	6.16	403.5	110.11	14.90
					4	1.23	6.94	428.7	137.74	13.31
					5	2.48	6.18	399.1	115.89	14.78
					6	1.31	6.95	430.7	137.11	13.29

Appendix B
Detailed Exhaust Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	NOx	HC	CO2	CO	MPG
						Exhaust Emissions (grams/mile)				
SB-27	9.0	95	NYCC	10-19-90	1	4.57	14.57	1083.7	194.36	6.19
					2	3.97	10.47	1001.1	126.56	7.20
					3	4.02	11.01	984.4	143.11	7.14
					4	3.58	11.81	953.4	177.75	6.99
					5	3.50	11.57	941.1	176.20	7.08
					6	3.48	11.67	928.2	183.86	7.08
SB-28	9.0	95	LA-4	10-02-90	1	1.51	0.64	324.8	5.93	26.43
					2	0.42	0.08	349.5	2.33	25.13
					3	0.80	0.10	301.7	3.86	28.83
					4	0.74	0.08	337.3	4.21	25.81
					5	0.88	0.11	293.6	4.81	29.46
					6	0.62	0.08	338.8	3.39	25.80
SB-29	9.0	95	LA-4	10-15-90	1	4.23	3.35	527.3	35.44	14.96
					2	2.76	3.01	569.9	54.65	13.35
					3	4.20	2.64	485.9	46.55	15.65
					4	2.53	3.19	548.8	71.27	13.24
					5	4.38	2.58	481.2	47.23	15.76
					6	2.77	3.21	563.3	70.62	12.98
SB-29	9.0	105	NYCC	10-17-90	1	5.65	7.89	1145.8	135.67	6.42
					2	5.44	6.09	1055.2	146.66	6.81
					3	5.13	6.81	1047.1	199.58	6.43
					4	4.04	7.29	999.1	245.02	6.31
					5	3.87	6.92	1005.6	229.56	6.40
					6	3.76	7.57	1003.5	267.93	6.13
SB-29	9.0	95	NYCC	10-20-90	1	4.17	8.48	1222.5	159.00	5.92
					2	4.47	6.41	1098.5	172.81	6.39
					3	3.70	6.88	1031.7	227.87	6.29
					4	3.67	7.09	1041.7	250.14	6.10
					5	3.63	7.29	1035.1	257.90	6.07
					6	3.48	7.07	1044.5	255.65	6.10
SB-30	9.0	95	LA-4	10-11-90	1	3.60	5.96	550.6	115.92	11.82
					2	2.76	6.36	593.1	134.73	10.77
					3	2.87	6.16	528.7	151.91	11.29
					4	2.75	6.80	580.9	150.38	10.59
					5	2.94	6.21	524.4	154.69	11.28
					6	2.91	6.78	578.3	149.49	10.64
SB-30	9.0	105	NYCC	10-15-90	1	5.87	13.22	1034.1	158.61	6.70
					2	4.40	11.92	998.9	204.70	6.54
					3	4.30	12.72	998.3	220.37	6.41
					4	4.30	12.81	994.1	230.82	6.36
					5	4.11	12.47	979.5	247.98	6.31
					6	4.23	13.31	997.2	274.86	6.04

Appendix B
Detailed Exhaust Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	NOx	HC	CO2	CO	MPG
						Exhaust Emissions (grams/mile)				
SB-30	9.0	105	LA-4	10-17-90	1	3.27	5.88	509.2	144.01	11.78
					2	2.94	6.67	543.5	153.15	11.03
					3	3.15	6.66	494.8	176.49	11.20
					4	3.19	7.01	540.3	164.02	10.83
					5	2.92	6.56	479.3	181.60	11.31
					6	2.96	7.19	526.5	173.34	10.81
SB-30	7.5	95	NYCC	10-23-90	1	4.87	14.53	1031.9	181.87	6.51
					2	3.08	13.44	960.6	247.08	6.38
					3	3.10	14.45	970.0	257.78	6.25
					4	3.47	13.24	984.0	241.84	6.32
					5	3.39	13.75	980.3	249.87	6.27
					6	3.64	14.04	975.3	244.87	6.32
SB-31	9.0	95	LA-4	10-16-90	1	0.80	0.30	259.1	3.42	33.46
					2	0.62	0.07	291.1	1.84	30.19
					3	0.75	0.09	233.6	3.76	37.04
					4	0.63	0.10	283.2	4.61	30.55
					5	0.72	0.17	230.7	6.06	36.90
					6	0.77	0.09	282.6	3.27	30.84
SB-32	9.0	95	LA-4	11-05-90	1	0.71	0.45	335.4	4.46	25.83
					2	0.08	0.06	332.0	0.85	26.63
					3	0.34	0.08	299.6	2.03	29.31
					4	0.27	0.06	332.4	1.49	26.52
					5	0.36	0.09	305.3	2.63	28.68
					6	0.20	0.07	329.4	1.59	26.75
SB-32	7.5	105	NYCC	11-08-90	1	1.16	0.97	641.1	8.55	13.51
					2	0.13	0.22	613.9	2.94	14.34
					3	0.13	0.21	600.5	4.40	14.61
					4	0.19	0.25	608.6	5.91	14.36
					5	0.21	0.26	598.2	6.82	14.57
					6	0.20	0.30	588.2	8.26	14.75
SB-32	7.5	105	NYCC	11-09-90	1	1.53	1.28	676.4	8.20	12.81
					2	0.25	0.21	640.5	2.95	13.75
					3	0.19	0.20	597.9	3.64	14.70
					4	0.27	0.22	610.0	4.50	14.38
					5	0.27	0.21	605.6	4.70	14.47
					6	0.31	0.24	597.9	5.75	14.62
SB-33	9.0	95	LA-4	10-22-90	1	0.95	2.24	427.4	20.26	19.05
					2	0.32	0.12	377.3	3.69	23.16
					3	0.37	0.14	362.6	5.58	23.89
					4	0.32	0.44	364.1	17.47	22.60
					5	0.35	0.51	350.5	19.61	23.20
					6	0.30	1.86	319.4	69.41	20.45

Appendix B
Detailed Exhaust Emission Results

Veh	Fuel	°F	Cycle	Test Date	Bag	Exhaust Emissions (grams/mile) NOx	HC	CO2	CO	MPG
SB-33	9.0	95	NYCC	11-01-90	1	2.70	1.98	690.2	19.67	12.21
					2	1.23	0.40	639.3	11.90	13.47
					3	1.13	0.89	599.9	30.39	13.66
					4	1.01	1.41	587.0	46.40	13.37
					5	0.98	1.95	584.3	56.06	13.09
					6	1.22	0.51	631.3	11.28	13.65
SB-33	7.5	95	NYCC	11-02-90	1	2.69	1.85	703.7	21.11	11.96
					2	1.31	0.34	644.3	8.35	13.49
					3	1.27	0.34	637.4	9.36	13.60
					4	1.26	0.42	636.3	13.56	13.48
					5	1.11	0.45	635.3	14.36	13.47
					6	1.11	0.37	631.3	11.01	13.67
SB-34	9.0	95	LA-4	10-31-90	1	3.65	1.80	299.2	9.57	27.77
					2	3.13	1.48	300.6	5.12	28.35
					3	4.54	1.46	281.8	11.71	29.14
					4	3.56	1.48	308.7	5.03	27.64
					5	4.93	1.45	278.6	10.87	29.58
					6	3.26	1.45	281.1	7.30	29.89
SB-35	9.0	95	LA-4	11-26-90	1	4.36	1.00	360.5	9.58	23.45
					2	2.49	0.44	386.1	8.18	22.19
					3	3.42	0.32	328.8	8.11	25.93
					4	2.65	0.43	378.3	8.63	22.59
					5	3.40	0.31	317.0	6.90	27.01
					6	2.70	0.40	374.7	7.77	22.88
SB-35	9.0	105	LA-4	11-30-90	1	3.28	0.79	347.1	7.40	24.59
					2	1.92	0.38	376.6	7.28	22.82
					3	2.71	0.28	322.7	5.20	26.78
					4	1.99	0.42	373.4	8.58	22.88
					5	2.79	0.33	318.8	6.53	26.91
					6	1.98	0.46	364.3	10.61	23.22
SB-35	7.5	95	NYCC	12-03-90	1	5.62	3.23	770.9	28.76	10.75
					2	3.57	1.20	683.6	16.56	12.45
					3	3.55	1.15	676.0	17.00	12.58
					4	3.74	1.16	686.1	16.50	12.41
					5	3.82	1.15	681.7	15.59	12.51
					6	3.75	1.21	673.5	17.11	12.61
SB-35	9.0	105	NYCC	12-04-90	1	5.07	2.83	725.2	24.67	11.49
					2	3.40	1.17	675.9	18.21	12.54
					3	3.47	1.04	673.1	16.37	12.65
					4	3.53	1.11	675.4	16.69	12.60
					5	3.68	1.17	666.1	18.55	12.71
					6	3.75	1.26	676.3	18.44	12.52

Appendix C
Test Conditions

Veh	Fuel	°F	Cycle	Test Date	Bag	Temps Dry	Temps Wet	Baro	Miles	Comments
ARB-1	9.0	95	LA-4	09-20-89	1	95	78	29.30	3.609	Original Gas Cap
					2	95	79	29.30	3.878	
					3	96	78	29.30	3.605	
					4	96	77	29.30	3.892	
					5	96	77	29.30	3.603	
					6	96	77	29.30	3.872	
ARB-1	9.0	95	LA-4	09-21-89	1	95	79	29.31	3.603	Replacement Cap
					2	96	80	29.31	3.888	
					3	96	80	29.31	3.603	
					4	96	79	29.31	3.868	
					5	96	78	29.31	3.593	
					6	96	78	29.31	3.857	
ARB-2	9.0	95	LA-4	09-15-89	1	98	83	29.29	3.615	Baseline
					2	96	84	29.29	3.888	
					3	96	84	29.29	3.606	
					4	96	85	29.29	3.882	
					5	96	84	29.29	3.597	
					6	96	85	29.29	3.887	
ARB-2	9.0	105	LA-4	09-22-89	1	105	84	28.98	3.625	
					2	106	86	28.98	3.888	
					3	106	86	28.98	3.606	
					4	106	87	28.98	3.893	
					5	106	87	28.98	3.616	
					6	106	88	28.98	3.881	
ARB-2	9.0	95	NYCC	09-23-89	1	96	77	29.38	1.127	
					2	95	78	29.38	1.179	
					3	95	79	29.38	1.176	
					4	96	79	29.38	1.177	
					5	96	78	29.38	1.177	
					6	96	78	29.38	1.184	
ARB-2	7.5	95	LA-4	09-26-89	1	95	73	29.40	3.596	
					2	95	75	29.40	3.855	
					3	95	77	29.40	3.588	
					4	95	78	29.40	3.862	
					5	96	78	29.40	3.577	
					6	95	79	29.40	3.840	
ARB-3	9.0	95	LA-4	09-18-89	1	97	78	29.34	3.619	Baseline
					2	96	78	29.34	3.605	
					3	98	80	29.34	3.610	
					4	96	78	29.34	3.881	
					5	97	80	29.34	3.596	
					6	96	78	29.34	3.878	

Appendix C
Test Conditions

Veh	Fuel	°F	Cycle	Test Date	Bag	Temps Dry	Temps Wet	Baro	Miles	Comments
ARB-4	9.0	95	LA-4	09-14-89	1	95	80	29.20	3.601	As Received
					2	95	81	29.20	3.933	
					3	95	81	29.20	3.604	
					4	95	81	29.20	3.881	
					5	95	81	29.20	3.603	
					6	95	82	29.20	3.883	
ARB-4	9.0	95	LA-4	09-21-89	1	95	78	29.25	3.589	After Repairs
					2	95	80	29.25	3.861	
					3	96	80	29.25	3.583	
					4	96	80	29.25	3.861	
					5	96	80	29.25	3.595	
					6	96	79	29.25	3.865	
ARB-5	9.0	95	LA-4	09-20-89	1	96	77	29.36	3.610	Baseline
					2	95	78	29.36	3.885	
					3	95	77	29.36	3.597	
					4	95	78	29.36	3.879	
					5	96	78	29.36	3.598	
					6	96	78	29.36	3.882	
ARB-5	9.0	105	NYCC	09-22-89	1	106	83	28.96	1.215	
					2	106	85	28.96	1.216	
					3	105	85	28.96	1.212	
					4	105	86	28.96	1.199	
					5	106	86	28.96	1.209	
					6	106	87	28.96	1.197	
ARB-5	7.5	95	LA-4	09-26-89	1	95	73	29.45	3.599	
					2	96	75	29.45	3.857	
					3	95	78	29.45	3.586	
					4	96	78	29.45	3.861	
					5	96	79	29.45	3.588	
					6	96	78	29.45	3.872	
ARB-5	9.0	95	NYCC	09-27-89	1	96	73	29.67	1.176	
					2	96	74	29.67	1.182	
					3	95	75	29.67	1.193	
					4	96	76	29.67	1.191	
					5	96	76	29.67	1.179	
					6	96	77	29.67	1.180	
ARB-6	9.0	95	LA-4	09-21-89	1	96	79	29.27	3.593	Replacement Cap
					2	96	79	29.27	3.858	
					3	96	80	29.27	3.604	
					4	96	78	29.27	3.863	
					5	96	78	29.27	3.608	
					6	96	79	29.27	3.874	

Appendix C
Test Conditions

Veh	Fuel	°F	Cycle	Test Date	Bag	Temps Dry	Temps Wet	Baro	Miles	Comments
ARB-6	9.0	95	LA-4	09-22-89	1	96	80	28.87	3.631	Original Gas Cap
					2	96	78	28.87	3.914	
					3	96	78	28.87	3.606	
					4	96	78	28.87	3.907	
					5	96	77	28.87	3.622	
					6	96	77	28.87	3.919	
SB-1	9.0	95	LA-4	10-17-89	1	95	74	29.26	3.607	Baseline
					2	95	76	29.26	3.867	
					3	95	78	29.26	3.588	
					4	96	78	29.26	3.875	
					5	95	79	29.26	3.592	
					6	96	78	29.26	3.863	
SB-2	9.0	95	LA-4	10-05-89	1	94	74	29.07	3.617	Baseline
					2	96	76	29.07	3.900	
					3	95	78	29.07	3.603	
					4	95	79	29.07	3.881	
					5	96	80	29.07	3.602	
					6	96	82	29.07	3.884	
SB-3	9.0	95	LA-4	10-17-89	1	96	77	29.29	3.612	Baseline
					2	95	79	29.29	3.882	
					3	96	79	29.29	3.598	
					4	96	79	29.29	3.891	
					5	96	80	29.29	3.618	
					6	96	80	29.29	3.900	
SB-4	9.0	95	LA-4	10-06-89	1	96	76	29.05	3.588	Baseline
					2	96	78	29.05	3.872	
					3	95	79	29.05	3.589	
					4	96	80	29.05	3.862	
					5	95	78	29.05	3.589	
					6	96	79	29.05	3.873	
SB-5	9.0	95	LA-4	10-27-89	1	96	76	29.37	3.613	Baseline
					2	96	78	29.37	3.891	
					3	96	80	29.37	3.604	
					4	96	81	29.37	3.877	
					5	96	81	29.37	3.622	
					6	96	82	29.37	3.880	
SB-6	9.0	95	LA-4	03-06-90	1	95	74	29.63	3.607	Replicate
					2	95	75	29.63	3.832	
					3	95	76	29.63	3.592	
					4	95	77	29.63	3.824	
					5	95	77	29.63	3.586	
					6	95	78	29.63	3.825	

Appendix C
Test Conditions

Veh	Fuel	°F	Cycle	Test Date	Bag	Temps Dry	Temps Wet	Baro	Miles	Comments
SB-6	9.0	95	LA-4	03-08-90	1	95	75	29.47	3.580	Baseline
					2	95	77	29.47	3.848	
					3	96	79	29.47	3.601	
					4	95	79	29.47	3.834	
					5	95	80	29.47	3.586	
					6	95	80	29.47	3.848	
SB-6	9.0	105	LA-4	03-16-90	1	105	80	29.01	3.592	Proposed Proced.
					2	105	81	29.01	3.863	
					3	105	82	29.01	3.586	
					4	105	83	29.01	3.854	
					5	105	83	29.01	3.583	
					6	105	84	29.01	3.858	
SB-7	9.0	95	LA-4	03-15-90	1	95	73	29.02	3.575	Baseline
					2	95	76	29.02	3.812	
					3	95	78	29.02	3.558	
					4	95	79	29.04	3.797	
					5	95	79	29.04	3.531	
					6	95	80	29.04	3.807	
SB-7	9.0	105	LA-4	03-19-90	1	105	79	29.46	3.568	Proposed proced.
					2	105	80	29.46	3.817	
					3	105	81	29.46	3.553	
					4	105	83	29.46	3.826	
					5	105	84	29.46	3.566	
					6	105	84	29.46	3.822	
SB-8	9.0	95	LA-4	04-04-90	1	95	73	28.93	3.610	Baseline
					2	95	74	28.93	3.884	
					3	96	76	28.93	3.598	
					4	95	77	28.93	3.889	
					5	95	78	28.93	3.601	
					6	95	78	28.93	3.889	
SB-10	9.0	95	LA-4	08-29-90	1	97	72	29.08	3.581	Baseline
					2	97	75	29.08	3.864	
					3	97	76	29.08	3.587	
					4	97	75	29.08	3.854	
					5	98	77	29.08	3.582	
					6	97	76	29.08	3.882	
SB-10	9.0	105	NYCC	08-31-90	1	107	79	29.31	1.198	
					2	107	80	29.31	1.194	
					3	106	80	29.31	1.208	
					4	106	81	29.31	1.206	
					5	106	81	29.31	1.194	
					6	106	81	29.31	1.200	

Appendix C
Test Conditions

Veh	Fuel	°F	Cycle	Test Date	Bag	Temps Dry	Temps Wet	Baro	Miles	Comments
SB-10	9.0	95	LA-4	09-07-90	1	96	78	29.05	3.598	Replicate
					2	99	79	29.05	3.849	
					3	97	79	29.05	3.579	
					4	99	78	29.05	3.868	
					5	99	78	29.05	3.571	
					6	97	76	29.05	3.875	
SB-10	9.0	95	NYCC	09-10-90	1	96	76	29.26	1.186	
					2	97	76	29.26	1.197	
					3	96	76	29.26	1.195	
					4	96	76	29.26	1.199	
					5	96	76	29.26	1.209	
					6	96	77	29.26	1.201	
SB-10	7.5	95	LA-4	09-12-90	1	95	73	29.35	3.596	
					2	96	75	29.35	3.873	
					3	96	77	29.35	3.588	
					4	97	77	29.35	3.867	
					5	97	77	29.35	3.607	
					6	96	76	29.35	3.879	
SB-11	9.0	95	LA-4	08-30-90	1	96	74	29.24	3.612	Baseline
					2	96	75	29.24	3.904	
					3	96	75	29.24	3.592	
					4	96	74	29.24	3.878	
					5	96	75	29.24	3.614	
					6	96	76	29.24	3.882	
SB-12	9.0	95	LA-4	09-10-90	1	96	79	29.26	3.600	Baseline
					2	96	78	29.26	3.890	
					3	97	78	29.26	3.601	
					4	97	77	29.26	3.894	
					5	97	77	29.26	3.593	
					6	96	76	29.26	3.899	
SB-12	9.0	95	NYCC	09-12-90	1	97	76	29.34	1.206	
					2	96	76	29.34	1.191	
					3	97	77	29.34	1.184	
					4	97	76	29.34	1.195	
					5	97	77	29.34	1.190	
					6	97	77	29.34	1.194	
SB-12	7.5	95	LA-4	09-13-90	1	95	72	29.28	3.597	
					2	96	74	29.28	3.888	
					3	97	76	29.28	3.592	
					4	97	76	29.28	3.878	
					5	97	76	29.28	3.583	
					6	97	76	29.28	3.872	

Appendix C
Test Conditions

Veh	Fuel	°F	Cycle	Test Date	Bag	Temps Dry	Temps Wet	Baro	Miles	Comments
SB-12	9.0	105	NYCC	09-14-90	1	104	75	29.01	1.208	
					2	106	77	29.01	1.205	
					3	107	78	29.01	1.197	
					4	106	79	29.01	1.210	
					5	106	79	29.01	1.198	
					6	106	80	29.01	1.199	
SB-12	9.0	105	LA-4	09-18-90	1	106	72	29.52	3.616	
					2	106	73	29.52	3.894	
					3	106	75	29.52	3.589	
					4	106	75	29.52	3.889	
					5	107	77	29.52	3.589	
					6	106	77	29.52	3.829	
SB-12	9.0	80	LA-4	09-19-90	1	81	69	29.16	3.642	Fuel Temps High
					2	82	68	29.16	3.916	
					3	83	68	29.16	3.621	
					4	82	67	29.16	3.940	
					5	83	68	29.16	3.619	
					6	84	68	29.16	3.932	
SB-13	9.0	95	LA-4	09-27-90	1	97	71	29.26	3.624	Baseline
					2	96	73	29.26	3.903	Carb bowl moist
					3	96	74	29.26	3.592	
					4	97	75	29.26	3.906	
					5	96	74	29.26	3.566	
					6	96	74	29.26	3.857	
SB-14	9.0	95	LA-4	09-05-90	1	97	73	29.28	3.604	Baseline
					2	97	75	29.28	3.891	
					3	97	76	29.28	3.589	
					4	97	76	29.28	3.877	
					5	98	77	29.28	3.583	
					6	97	76	29.28	3.884	
SB-15	9.0	95	LA-4	09-17-90	1	96	69	29.52	3.601	Baseline
					2	95	70	29.52	3.907	
					3	95	70	29.52	3.606	
					4	96	71	29.52	3.869	
					5	96	71	29.52	3.585	
					6	97	72	29.52	3.877	
SB-16	9.0	95	LA-4	09-24-90	1	96	67	29.29	3.573	Baseline
					2	95	68	29.29	3.833	
					3	96	69	29.29	3.542	
					4	96	70	29.29	3.811	
					5	96	71	29.29	3.569	
					6	96	72	29.29	3.866	

Appendix C
Test Conditions

Veh	Fuel	°F	Cycle	Test Date	Bag	Temps Dry	Temps Wet	Baro	Miles	Comments
SB-16	9.0	105	NYCC	09-28-90	1	106	75	29.25	1.181	
					2	105	75	29.25	1.183	
					3	105	77	29.25	1.173	
					4	105	77	29.25	1.181	
					5	106	78	29.25	1.197	
					6	105	78	29.25	1.166	
SB-16	9.0	105	LA-4	10-01-90	1	107	73	29.28	3.621	
					2	105	74	29.28	3.876	
					3	106	75	29.28	3.597	
					4	105	75	29.28	3.866	
					5	106	76	29.28	3.580	
					6	105	76	29.28	3.868	
SB-16	7.5	105	NYCC	10-02-90	1	104	72	29.39	1.180	
					2	105	73	29.39	1.180	
					3	105	74	29.39	1.180	
					4	105	74	29.39	1.180	
					5	105	75	29.39	1.180	
					6	105	76	29.39	1.180	
SB-17	9.0	95	LA-4	10-01-90	1	96	69	29.26	3.589	Baseline
					2	95	69	29.26	3.869	
					3	94	69	29.26	3.597	
					4	95	70	29.26	3.869	
					5	96	71	29.26	3.588	
					6	96	72	29.26	3.866	
SB-17	9.0	105	NYCC	10-04-90	1	104	75	29.11	1.182	
					2	105	76	29.11	1.194	
					3	106	77	29.11	1.191	
					4	106	78	29.11	1.192	
					5	106	79	29.11	1.198	
					6	105	78	29.11	1.195	
SB-17	7.5	105	NYCC	10-05-90	1	105	75	29.17	1.170	
					2	106	75	29.17	1.168	
					3	105	76	29.17	1.185	
					4	106	76	29.17	1.197	
					5	105	76	29.17	1.192	
					6	105	76	29.17	1.184	
SB-17	7.5	105	LA-4	10-10-90	1	105	74	29.00	3.590	
					2	105	74	29.00	3.867	
					3	105	75	29.00	3.611	
					4	105	75	29.00	3.904	
					5	105	76	29.00	3.615	
					6	105	76	29.00	3.907	

Appendix C
Test Conditions

Veh	Fuel	°F	Cycle	Test Date	Bag	Temps Dry	Wet	Baro	Miles	Comments
SB-18	9.0	95	LA-4	09-17-90	1	96	69	29.55	3.614	Baseline
					2	96	70	29.55	3.884	
					3	97	70	29.55	3.614	
					4	96	71	29.55	3.899	
					5	96	71	29.55	3.614	
					6	95	72	29.55	3.905	
SB-18	9.0	105	NYCC	09-19-90	1	105	74	29.11	1.191	
					2	105	76	29.11	1.193	
					3	105	77	29.11	1.186	
					4	105	77	29.11	1.191	
					5	105	78	29.11	1.184	
					6	105	78	29.11	1.205	
SB-18	7.5	105	NYCC	09-24-90	1	105	71	29.28	1.197	
					2	105	72	29.28	1.191	
					3	107	73	29.28	1.185	
					4	107	74	29.28	1.202	
					5	107	74	29.28	1.216	
					6	107	75	29.28	1.202	
SB-18	9.0	105	LA-4	09-27-90	1	104	74	29.24	3.608	
					2	104	75	29.24	3.908	
					3	105	76	29.24	3.595	
					4	105	77	29.24	3.896	
					5	106	77	29.24	3.598	
					6	106	78	29.24	3.874	
SB-18	9.0	105	LA-4	09-28-90	1	104	74	29.27	3.590	
					2	106	75	29.27	3.899	
					3	104	76	29.27	3.592	
					4	104	76	29.27	3.878	
					5	104	77	29.27	3.593	
					6	105	78	29.27	3.883	
SB-19	9.0	95	LA-4	09-13-90	1	98	79	29.17	3.576	Baseline
					2	97	78	29.17	3.847	
					3	97	78	29.17	3.584	
					4	97	77	29.17	3.849	
					5	97	77	29.17	3.577	
					6	98	79	29.17	3.839	
SB-19	9.0	105	NYCC	09-18-90	1	106	72	29.53	1.190	
					2	107	73	29.53	1.192	
					3	108	74	29.53	1.199	
					4	107	75	29.53	1.224	
					5	107	75	29.53	1.203	
					6	106	75	29.53	1.191	

Appendix C
Test Conditions

Veh	Fuel	°F	Cycle	Test Date	Bag	Temps Dry	Temps Wet	Baro	Miles	Comments
SB-19	9.0	95	NYCC	09-19-90	1	97	74	29.22	1.158	
					2	96	75	29.22	1.170	
					3	96	75	29.22	1.175	
					4	96	75	29.22	1.171	
					5	96	75	29.22	1.173	
					6	96	75	29.22	1.184	
SB-19	9.0	95	LA-4	09-20-90	1	99	72	29.44	3.614	Replicate
					2	99	73	29.44	3.899	
					3	97	74	29.44	3.611	
					4	90	75	29.44	3.878	
					5	98	76	29.44	3.601	
					6	98	76	29.44	3.892	
SB-19	7.5	105	NYCC	09-24-90	1	106	71	29.25	1.180	
					2	106	73	29.25	1.183	
					3	105	74	29.25	1.191	
					4	105	74	29.25	1.194	
					5	105	75	29.25	1.188	
					6	106	75	29.25	1.194	
SB-19	7.5	105	LA-4	09-27-90	1	105	77	29.24	3.581	
					2	105	78	29.24	3.832	
					3	105	78	29.24	3.559	
					4	106	80	29.24	3.841	
					5	106	80	29.24	3.566	
					6	106	80	29.24	3.845	
SB-20	9.0	95	LA-4	09-19-90	1	96	70	29.07	3.623	Baseline
					2	96	72	29.07	3.906	
					3	96	73	29.07	3.607	
					4	96	74	29.07	3.868	
					5	96	75	29.07	3.636	
					6	96	74	29.07	3.915	
SB-20	9.0	105	NYCC	09-24-90	1	106	72	29.22	1.193	
					2	106	73	29.22	1.189	
					3	105	74	29.22	1.170	
					4	107	74	29.22	1.182	
					5	107	75	29.22	1.181	
					6	107	76	29.22	1.181	
SB-20	7.5	105	NYCC	09-25-90	1	106	73	28.97	1.196	
					2	107	74	28.97	1.197	
					3	105	74	28.97	1.201	
					4	106	75	28.97	1.191	
					5	105	76	28.97	1.189	
					6	106	77	28.97	1.205	

Appendix C
Test Conditions

Veh	Fuel	°F	Cycle	Test Date	Bag	Temps Dry	Temps Wet	Baro	Miles	Comments
SB-21	9.0	95	LA-4	09-25-90	1	97	70	28.94	3.620	Baseline
					2	95	70	28.94	3.884	
					3	95	71	28.94	3.586	
					4	95	72	28.94	3.895	
					5	96	73	28.94	3.588	
					6	95	73	28.94	3.891	
SB-21	9.0	95	LA-4	09-27-90	1	97	75	29.17	3.578	Replicate
					2	97	75	29.17	3.847	
					3	95	76	29.17	3.571	
					4	95	76	29.17	3.843	
					5	95	75	29.17	3.572	
					6	95	76	29.17	3.845	
SB-22	9.0	95	LA-4	09-27-90	1	94	70	29.27	3.695	Baseline
					2	94	72	29.27	3.985	
					3	95	73	29.27	3.683	
					4	95	74	29.27	4.029	
					5	95	74	29.27	3.759	
					6	95	74	29.27	4.248	
SB-22	9.0	105	NYCC	10-02-90	1	106	73	29.35	1.154	
					2	105	74	29.35	1.161	
					3	106	74	29.35	1.149	
					4	106	75	29.35	1.164	
					5	106	76	29.35	1.165	
					6	106	77	29.35	1.170	
SB-22	7.5	105	NYCC	10-03-90	1	106	76	29.17	1.176	
					2	106	77	29.17	1.178	
					3	105	78	29.17	1.170	
					4	105	78	29.17	1.182	
					5	105	78	29.17	1.184	
					6	105	79	29.17	1.173	
SB-22	7.5	105	LA-4	10-04-90	1	106	76	29.10	3.560	
					2	106	77	29.10	3.846	
					3	106	78	29.10	3.573	
					4	106	79	29.10	3.856	
					5	107	79	29.10	3.564	
					6	105	79	29.10	3.850	
SB-23	9.0	95	LA-4	10-17-90	1	96	76	29.09	3.585	Baseline
					2	97	77	29.09	3.899	
					3	95	78	29.09	3.605	
					4	95	78	29.09	3.930	
					5	96	78	29.09	3.595	
					6	96	80	29.09	3.901	

Appendix C
Test Conditions

Veh	Fuel	°F	Cycle	Test Date	Bag	Temps Dry	Temps Wet	Baro	Miles	Comments
SB-23	7.5	95	NYCC	10-19-90	1	95	76	29.37	1.203	
					2	95	76	29.37	1.199	
					3	95	77	29.37	1.196	
					4	95	77	29.37	1.183	
					5	95	77	29.37	1.204	
					6	95	78	29.37	1.200	
SB-24	9.0	95	LA-4	10-09-90	1	94	70	29.32	3.616	Baseline
					2	95	72	29.32	3.878	
					3	95	74	29.32	3.583	
					4	95	74	29.32	3.876	
					5	94	74	29.32	3.595	
					6	96	75	29.32	3.875	
SB-24	9.0	105	NYCC	10-11-90	1	105	75	29.35	1.271	
					2	105	76	29.35	1.236	
					3	106	77	29.35	1.208	
					4	102	76	29.35	1.234	
					5	104	77	29.35	1.224	
					6	104	77	29.35	1.225	
SB-24	7.5	105	NYCC	10-15-90	1	104	77	29.18	1.204	
					2	104	78	29.18	1.207	
					3	104	78	29.18	1.212	
					4	104	78	29.18	1.215	
					5	103	78	29.18	1.208	
					6	103	78	29.18	1.226	
SB-24	7.5	105	LA-4	10-17-90	1	106	82	29.18	3.595	
					2	105	83	29.18	3.899	
					3	105	84	29.18	3.585	
					4	105	85	29.18	3.895	
					5	106	86	29.18	3.569	
					6	106	86	29.18	3.881	
SB-25	9.0	95	LA-4	10-09-90	1	95	68	29.28	3.612	Baseline
					2	96	70	29.28	3.918	
					3	96	71	29.28	3.586	
					4	97	73	29.28	3.878	
					5	97	74	29.28	3.589	
					6	96	74	29.28	3.881	
SB-25	9.0	105	NYCC	10-11-90	1	108	76	29.38	1.212	
					2	108	77	29.38	1.199	
					3	108	78	29.38	1.200	
					4	106	78	29.38	1.215	
					5	105	78	29.38	1.211	
					6	105	78	29.38	1.221	

Appendix C
Test Conditions

Veh	Fuel	°F	Cycle	Test Date	Bag	Temps Dry	Temps Wet	Baro	Miles	Comments
SB-25	7.5	105	NYCC	10-12-90	1	105	76	29.32	1.185	
					2	106	77	29.32	1.188	
					3	106	77	29.32	1.194	
					4	106	76	29.32	1.192	
					5	106	77	29.32	1.196	
					6	106	79	29.32	1.197	
SB-25	9.0	105	NYCC	10-16-90	1	109	82	29.40	1.194	replicate
					2	106	81	29.40	1.183	
					3	105	82	29.40	1.177	
					4	105	82	29.40	1.181	
					5	106	83	29.40	1.198	
					6	106	83	29.40	1.185	
SB-25	7.5	105	LA-4	10-19-90	1	105	80	29.41	3.620	
					2	105	82	29.41	3.885	
					3	105	84	29.41	3.594	
					4	106	84	29.41	3.899	
					5	106	85	29.41	3.593	
					6	106	86	29.41	3.942	
SB-26	9.0	95	LA-4	10-12-90	1	95	70	29.38	3.570	Baseline
					2	95	72	29.38	3.823	
					3	96	73	29.38	3.553	
					4	96	73	29.38	3.842	
					5	96	75	29.38	3.556	
					6	96	75	29.38	3.832	
SB-26	9.0	105	NYCC	10-17-90	1	106	86	29.02	1.212	
					2	105	86	29.02	1.181	
					3	105	86	29.02	1.197	
					4	106	86	29.02	1.188	
					5	105	86	29.02	1.185	
					6	106	86	29.02	1.171	
SB-26	9.0	95	NYCC	10-19-90	1	95	74	29.38	1.199	
					2	95	75	29.38	1.192	
					3	96	76	29.38	1.180	
					4	96	77	29.38	1.194	
					5	96	77	29.38	1.198	
					6	96	77	29.38	1.183	
SB-27	9.0	95	LA-4	10-18-90	1	95	75	28.98	3.589	Baseline
					2	95	76	28.98	3.877	
					3	95	77	28.98	3.576	
					4	96	79	28.98	3.873	
					5	96	80	28.98	3.589	
					6	96	81	28.98	3.878	

Appendix C
Test Conditions

Veh	Fuel	°F	Cycle	Test Date	Bag	Temps Dry	Temps Wet	Baro	Miles	Comments
SB-27	9.0	95	NYCC	10-19-90	1	94	74	29.38	1.206	
					2	94	75	29.38	1.191	
					3	95	75	29.38	1.192	
					4	95	76	29.38	1.185	
					5	94	77	29.38	1.194	
					6	95	78	29.38	1.227	
SB-28	9.0	95	LA-4	10-02-90	1	96	71	29.28	3.608	Baseline
					2	95	72	29.28	3.877	
					3	95	72	29.28	3.591	
					4	94	73	29.28	3.878	
					5	94	73	29.28	3.595	
					6	95	74	29.28	3.887	
SB-29	9.0	95	LA-4	10-15-90	1	98	74	29.35	3.618	Baseline
					2	97	74	29.35	3.912	
					3	96	74	29.35	3.607	
					4	97	75	29.35	3.920	
					5	97	76	29.35	3.620	
					6	96	77	29.35	3.909	
SB-29	9.0	105	NYCC	10-17-90	1	108	86	29.02	1.230	
					2	110	86	29.02	1.219	
					3	107	86	29.02	1.219	
					4	106	86	29.02	1.218	
					5	106	85	29.02	1.218	
					6	106	86	29.02	1.212	
SB-29	9.0	95	NYCC	10-20-90	1	95	74	29.38	1.176	
					2	96	76	29.38	1.179	
					3	96	76	29.38	1.183	
					4	96	77	29.38	1.178	
					5	93	76	29.38	1.183	
					6	93	76	29.38	1.173	
SB-30	9.0	95	LA-4	10-11-90	1	96	70	29.38	3.597	Baseline
					2	97	72	29.38	3.859	
					3	97	74	29.38	3.567	
					4	98	75	29.38	3.852	
					5	98	76	29.38	3.586	
					6	97	76	29.38	3.881	
SB-30	9.0	105	NYCC	10-15-90	1	106	79	29.28	1.194	
					2	105	79	29.28	1.195	
					3	106	80	29.28	1.188	
					4	105	80	29.28	1.194	
					5	105	80	29.28	1.201	
					6	105	80	29.28	1.205	

Appendix C
Test Conditions

Veh	Fuel	°F	Cycle	Test Date	Bag	Temps Dry	Temps Wet	Baro	Miles	Comments
SB-30	9.0	105	LA-4	10-17-90	1	106	83	29.09	3.603	
					2	106	85	29.09	3.916	
					3	106	86	29.09	3.585	
					4	106	86	29.09	3.888	
					5	106	86	29.09	3.582	
					6	106	86	29.09	3.879	
SB-30	7.5	95	NYCC	10-23-90	1	96	71	29.31	1.182	
					2	95	72	29.31	1.209	
					3	96	73	29.31	1.194	
					4	96	73	29.31	1.191	
					5	96	73	29.31	1.193	
					6	96	74	29.31	1.205	
SB-31	9.0	95	LA-4	10-16-90	1	94	74	29.18	3.598	Baseline
					2	95	75	29.18	3.888	
					3	95	76	29.18	3.596	
					4	95	77	29.18	3.888	
					5	95	77	29.18	3.592	
					6	95	78	29.18	3.878	
SB-32	9.0	95	LA-4	11-05-90	1	95	79	28.84	3.593	Baseline
					2	95	79	28.84	3.860	
					3	94	79	28.84	3.592	
					4	94	80	28.84	3.859	
					5	95	81	28.84	3.604	
					6	95	81	28.84	3.881	
SB-32	7.5	105	NYCC	11-08-90	1	95	79	29.50	1.478	
					2	95	80	29.50	1.188	
					3	95	80	29.50	1.187	
					4	95	80	29.50	1.177	
					5	95	81	29.50	1.196	
					6	95	81	29.50	1.179	
SB-32	7.5	105	NYCC	11-09-90	1	105	86	29.12	1.165	
					2	105	87	29.12	1.173	
					3	105	87	29.12	1.176	
					4	104	87	29.12	1.168	
					5	105	87	29.12	1.166	
					6	105	88	29.12	1.166	
SB-33	9.0	95	LA-4	10-22-90	1	96	69	29.34	3.594	Baseline
					2	96	71	29.34	3.896	
					3	96	71	29.34	3.602	
					4	96	72	29.34	3.874	
					5	96	72	29.34	3.583	
					6	97	73	29.34	3.865	

Appendix C
Test Conditions

Veh	Fuel	°F	Cycle	Test Date	Bag	Temps Dry	Temps Wet	Baro	Miles	Comments
SB-33	9.0	95	NYCC	11-01-90	1	96	73	29.33	1.183	
					2	97	75	29.33	1.187	
					3	96	75	29.33	1.203	
					4	96	76	29.33	1.212	
					5	96	76	29.33	1.213	
					6	96	77	29.33	1.201	
SB-33	7.5	95	NYCC	11-02-90	1	95	75	29.23	1.140	
					2	95	76	29.23	1.156	
					3	95	77	29.23	1.156	
					4	95	78	29.23	1.149	
					5	95	78	29.23	1.150	
					6	95	78	29.23	1.157	
SB-34	9.0	95	LA-4	10-31-90	1	94	73	29.36	4.303	Baseline
					2	95	75	29.36	3.842	
					3	97	77	29.36	3.627	
					4	96	78	29.36	3.854	
					5	98	79	29.36	3.592	
					6	95	79	29.36	4.048	
SB-35	9.0	95	LA-4	11-26-90	1	95	75	29.17	3.603	Baseline
					2	95	76	29.17	3.881	
					3	95	77	29.17	3.608	
					4	95	77	29.17	3.891	
					5	95	78	29.17	3.585	
					6	95	78	29.17	3.876	
SB-35	9.0	105	LA-4	11-30-90	1	105	69	29.51	3.632	
					2	104	69	29.51	3.921	
					3	106	71	29.51	3.625	
					4	106	72	29.51	3.888	
					5	106	73	29.51	3.628	
					6	107	73	29.51	3.945	
SB-35	7.5	95	NYCC	12-03-90	1	96	67	28.87	1.204	
					2	95	68	28.87	1.230	
					3	95	68	28.87	1.221	
					4	94	68	28.87	1.221	
					5	94	69	28.87	1.211	
					6	95	69	28.87	1.224	
SB-35	9.0	105	NYCC	12-04-90	1	105	72	29.41	1.191	
					2	104	73	29.41	1.202	
					3	105	74	29.41	1.202	
					4	107	75	29.41	1.201	
					5	104	75	29.41	1.198	
					6	104	75	29.41	1.200	