3.3 Dynamometer Emissions Experiments

3.3.1 Comparison of UCLA Freeway and Urban Driving Schedules to On-Road Driving Patterns and the FTP

The vehicle operating parameters for UCLA freeway and urban dynamometer driving schedules, the FTP and the patterns from which the driving schedules were developed from are given in Table 3.3.1.1. The average speeds of the new patterns were slightly lower than the patterns from which they were developed (33.3 versus 36.5 mph for the on-road freeway experiment, and 19.8 versus 20.7 mph for the on-road urban experiment). The freeway pattern had a higher average speed than the measured average speed for the FTP driving on the dynamometer (20.3 mph), but the average speed for the urban pattern was close to the FTP. The maximum velocity for the freeway pattern was lower than the on-road pattern it was developed from, (66.8 versus 72.9 mph) but was approximately 11 mph higher than the measured maximum speed of the FTP (56 mph). The maximum speed of the freeway dynamometer driving pattern was reduced when the pattern was developed due to maximum speed limitations of the dynamometer used for the tests. The maximum speed for the urban pattern and on-road data were the same (49.3 mph) but were lower than the maximum speed of the FTP.

The maximum rates of acceleration for the freeway and urban patterns were the same as for the on-road patterns they were developed from (4.5 and 7.1 mph s^{-1} respectively). The maximum measured acceleration rate for the FTP tests on the dynamometer was 5.1 mph s^{-1} which is higher then the maximum rates specified in the FTP because there is a allowable range in which the vehicle can operate (2 mph s^{-1}) which allows for the instantaneous acceleration to be slightly higher then specified. The same is true for the instantaneous maximum deceleration rate for the FTP which was measured as 4.26 mph s^{-1} compared to 6.73 mph s^{-1} for the freeway pattern and 7.37 mph s^{-1} for the urban pattern. The urban deceleration rate was reduced from 8.74 to 7.37 mph s^{-1} because the maximum deceleration rate on-road exceed the maximum recommended rate for the dynamometer.

The fuel economy was reduced by the shortening of the on-road patterns. This

Table 3.3.1.1 Comparison of UCLA Freeway and Urban Dynamometer Driving Schedules to the on-road routes they were developed from.

Route Number Dir, Expt#	Travel Time min	Travel Dist miles	Avg. Speed mph	Max Speed mph	Max Accel mph s-1	Max Decel mph s-1	Fuel Econ mpg	Open Loop Rich %	Open Loop Lean %	Avg Dist Per Stop miles
FTP										
Bags 1 & 2	22.9	7.27	20.3	55.96	5.08	4.26	22.9	0.00	0.00	0.45
Freeway										
7-EW-3	97.18	59.11	36.50	72.89	4.50	6.73	32.3	0.03	0.93	3.11
Dyno Pattern	23.35	12.96	33.34	66.79	4.50	6.73	28.4	0.14	0.64	2.16
Urban										
3-EW-42	104.28	35.99	20.71	49.31	7.10	8.74	22.8	0.02	0.02	0.44
Dyno Pattern	23.35	7.69	19.77	49.31	7.10	7.37	21.9	0.07	0.07	0.37

effect was greatest for the freeway on-road pattern in which the fuel economy decreased from 32.3 to 28.4 mph for the dynamometer pattern most likely because the highest fuel economy occurred at high speeds and the maximum speed of the on-road pattern was reduced in the creation of the dynamometer pattern.

The frequency of rich open loop operation was higher for the dynamometer patterns than for the on-road patterns, but the frequency of lean open loop operation for the freeway dynamometer pattern was less than the on-road pattern while the urban pattern was greater. Matching the percent time in open loop operation in the dynamometer pattern to the percent time on-road was the most difficult of the parameters to adjust. The reason was because of the low frequency and the length of the pattern; the frequency amounted to only a few seconds of open loop operation over the entire pattern.

The average distance between stops for the urban dynamometer pattern was slightly lower than the on-road pattern (0.37 versus 0.44 miles per stop) however it was still close to the average distance per stop in the FTP. The freeway dynamometer pattern had an approximately 33% lower distance per stop than the on-road pattern (3.1 versus 2.2 miles per stop), however, both were much higher then the FTP.

Probability plots for the UCLA freeway and urban dynamometer driving schedules are shown in Figures 3.3.1.1. and 3.3.1.2. These were subtracted from the equivalent on-road driving pattern probability plots (Figures 3.2.6.4. and 3.2.6.7.) to show the over- and under-estimation of the dynamometer driving schedules compared to the on-road patterns. The difference plot for the freeway driving schedule is shown in Figure 3.3.1.3. The freeway dynamometer driving schedule under-estimated the amount of time at high speeds, and over-estimated time at stop by 0.6% and the amount of time spent in cruise between 5 and 35 mph. The difference plot for the urban driving schedule is shown in Figure 3.3.1.4. The urban dynamometer driving schedule also under-estimated the amount of time at higher speeds (from 45 to 55 mph), and over-estimated time at stop by 0.4%. The urban dynamometer driving schedule over-estimated all acceleration and deceleration from 0 to 30 mph, but underestimated acceleration above approximately 45 mph.

The UCLA freeway and urban dynamometer driving schedules were averaged in three dimensions (Figure 3.3.1.5). The average of the driving schedules shows the distribution of the amount of time driving is spread over a wider range of speeds and velocities than the FTP. The average freeway and urban dynamometer driving pattern probability plot was subtracted from the average on-road driving conservative pattern plot (Figure 3.2.6.10) to determine the differences between the new dynamometer driving schedules and the on-road driving patterns. The result (Figure 3.3.1.6) is plotted with the same z scale as the over and under-estimation plot of the FTP (Figure 3.2.6.11) for comparison. The amount of time at stop for the new dynamometer patterns is over-estimated (0.6%) although it is much lower than the overestimation of the FTP (6.2%). The over-estimation of the urban cruise peak of the FTP does not appear with the new dynamometer driving schedules, and the under-estimation at high speeds was also eliminated.

3.3.2 Comparison of Bag Emissions to Second-by-Second Emissions

Differences were found between the emission rates calculated from the results of analyzing the "bag" emissions data and the one second emissions data for the

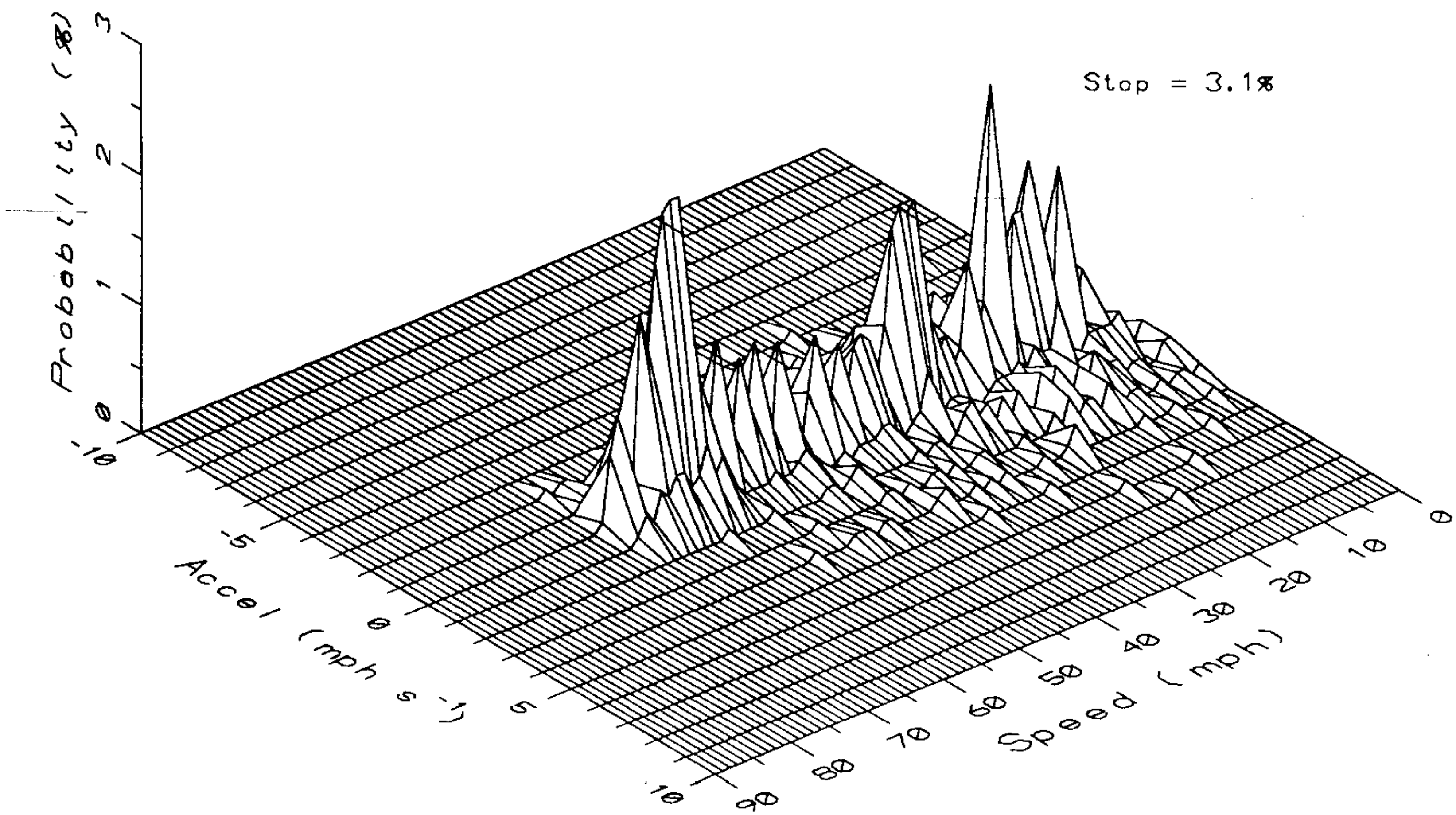

Figure 3.3.1.1 UCLA Freeway Dynamometer Driving Schedule as a function of probability of driving as a specific speed and acceleration.

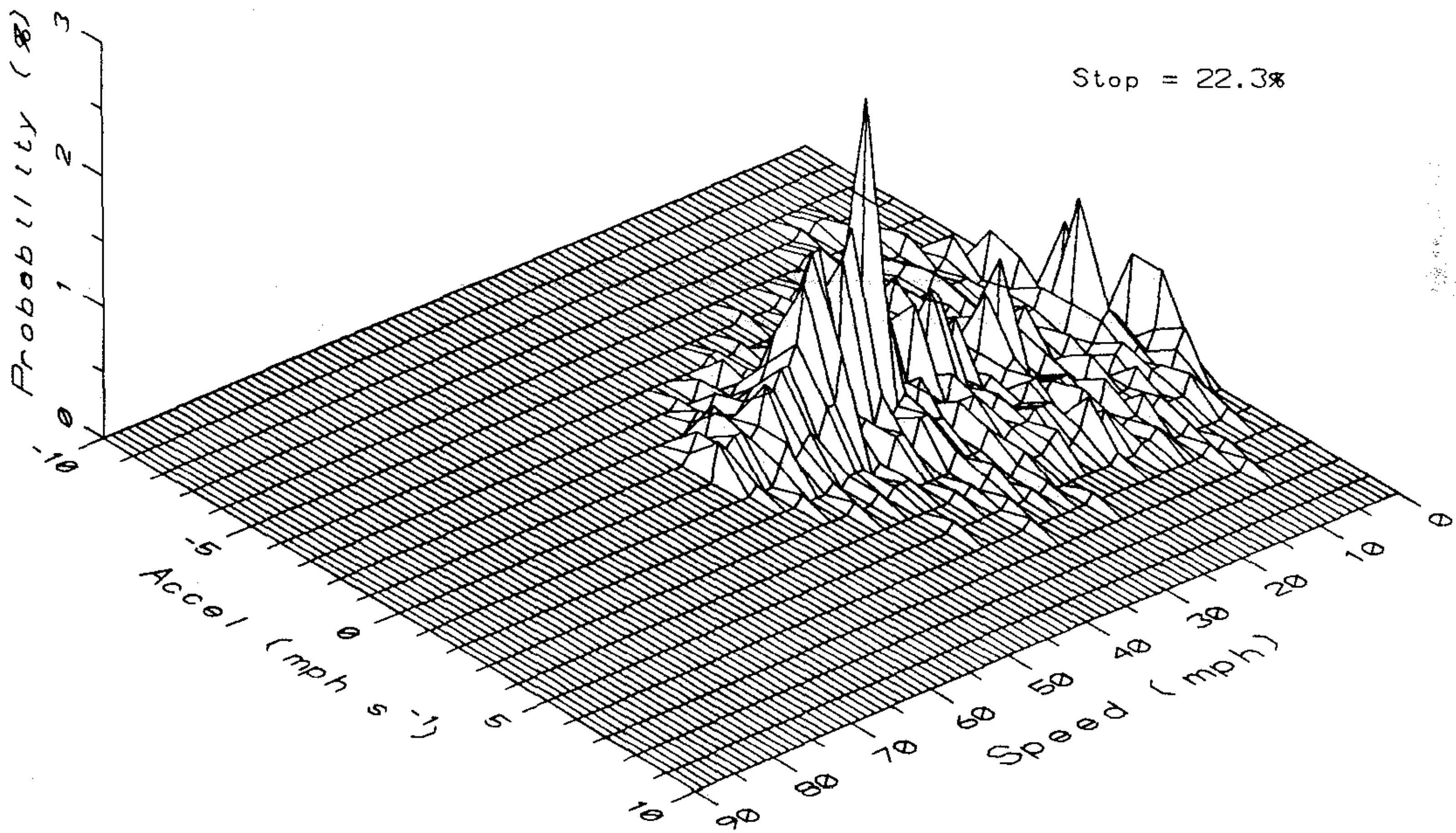

Figure 3.3.1.2 UCLA Urban Dynamometer Driving Schedule as a function of probability of driving as a specific speed and accèleration.

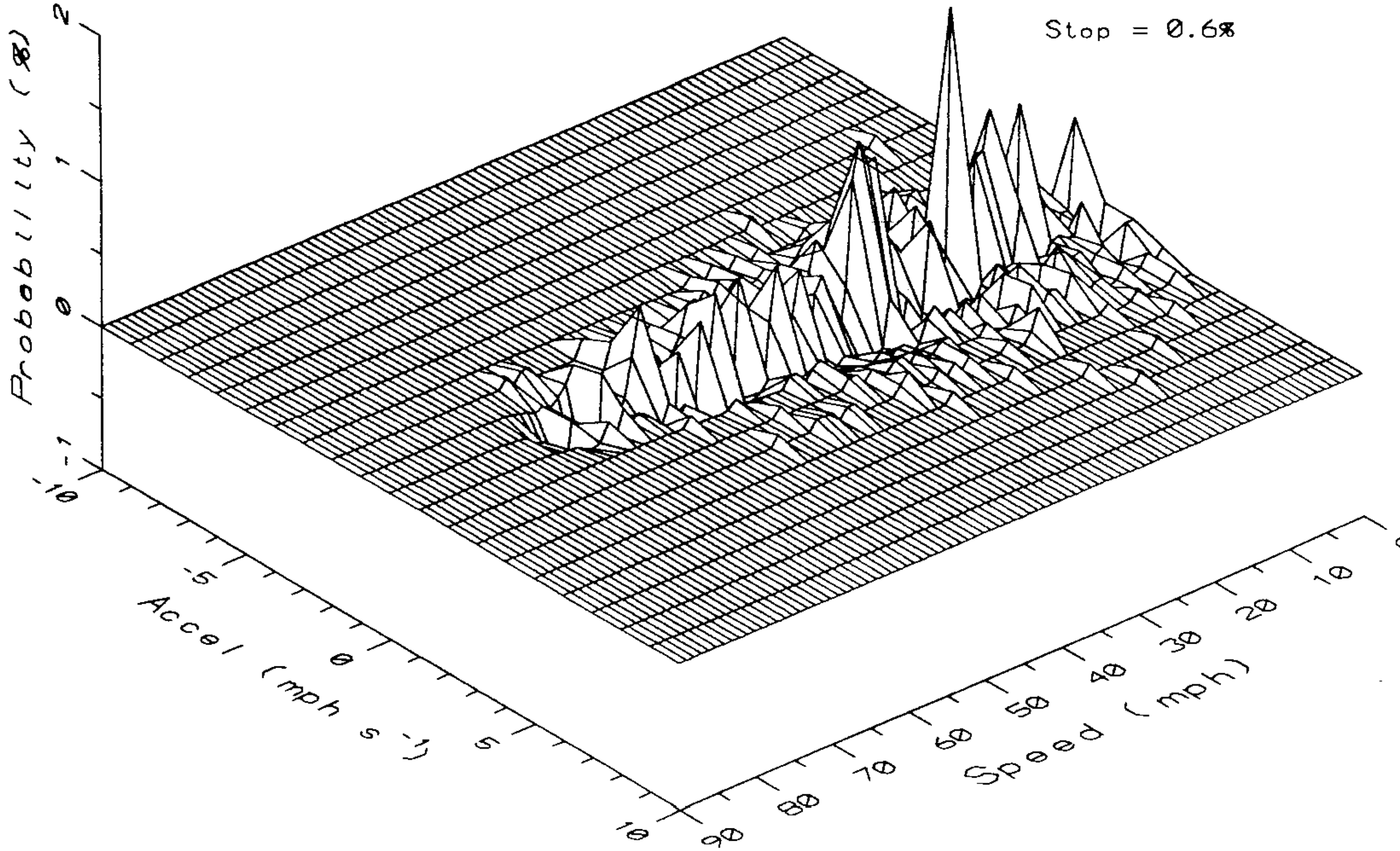

Figure 3.3.1.3 UCLA Freeway Dynamometer Driving Schedule minus on-road freeway conservative driving data.

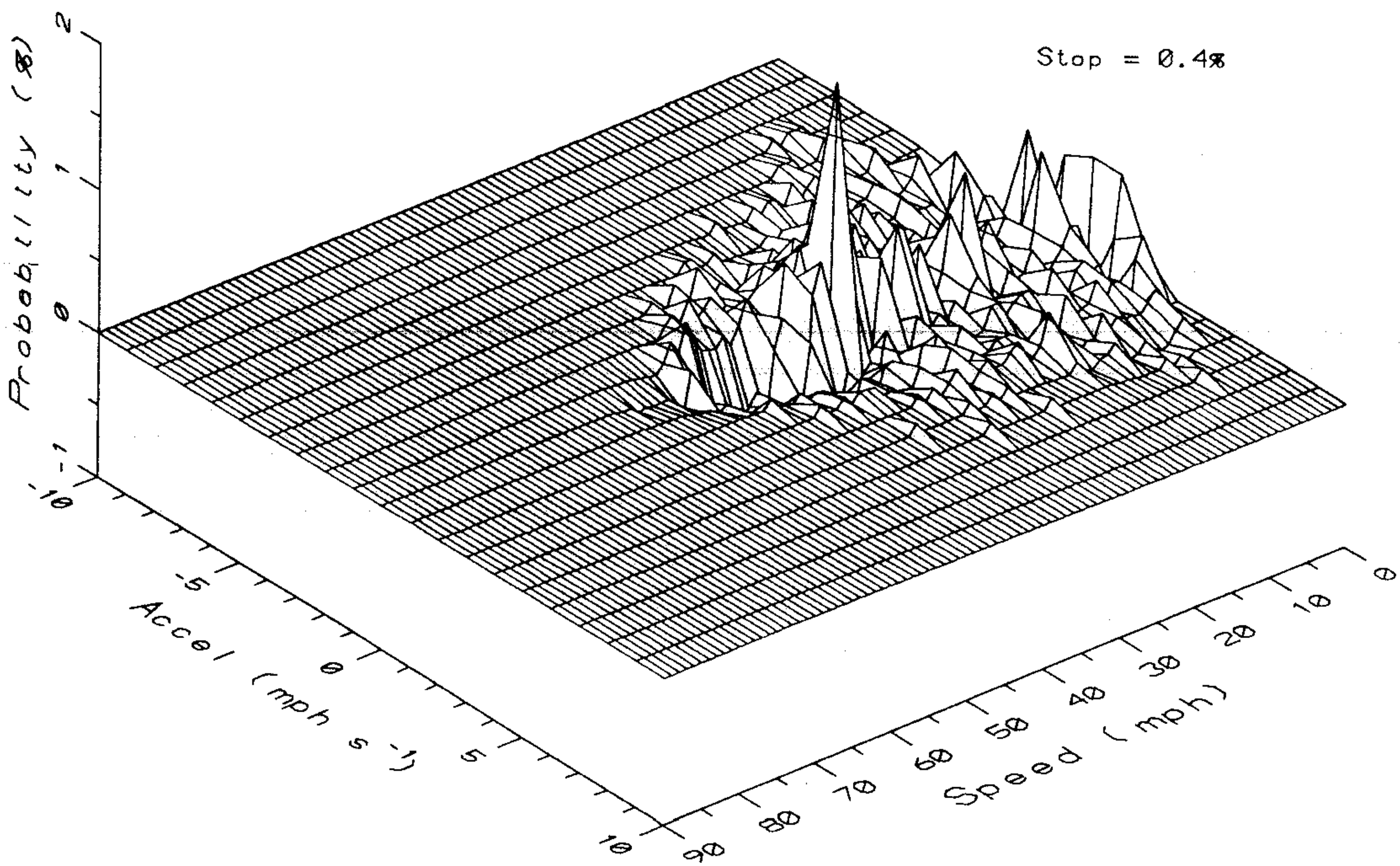

Figure 3.3.1.4 UCLA Urban Dynamometer Driving Schedule minus on-road urban conservative driving data.

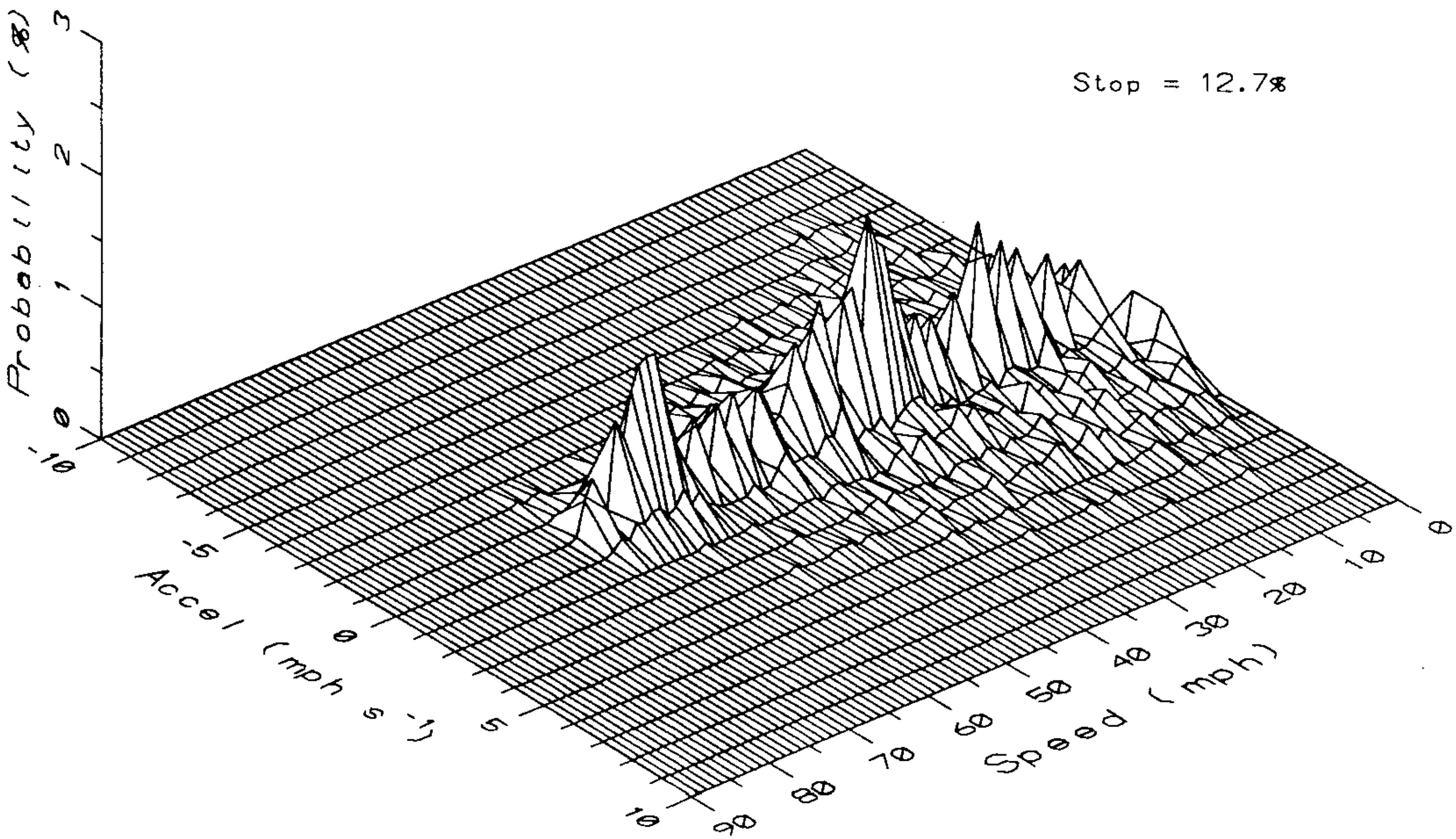

Figure 3.3.1.5 Average of the UCLA Freeway and Urban Dynamometer Driving Schedules.

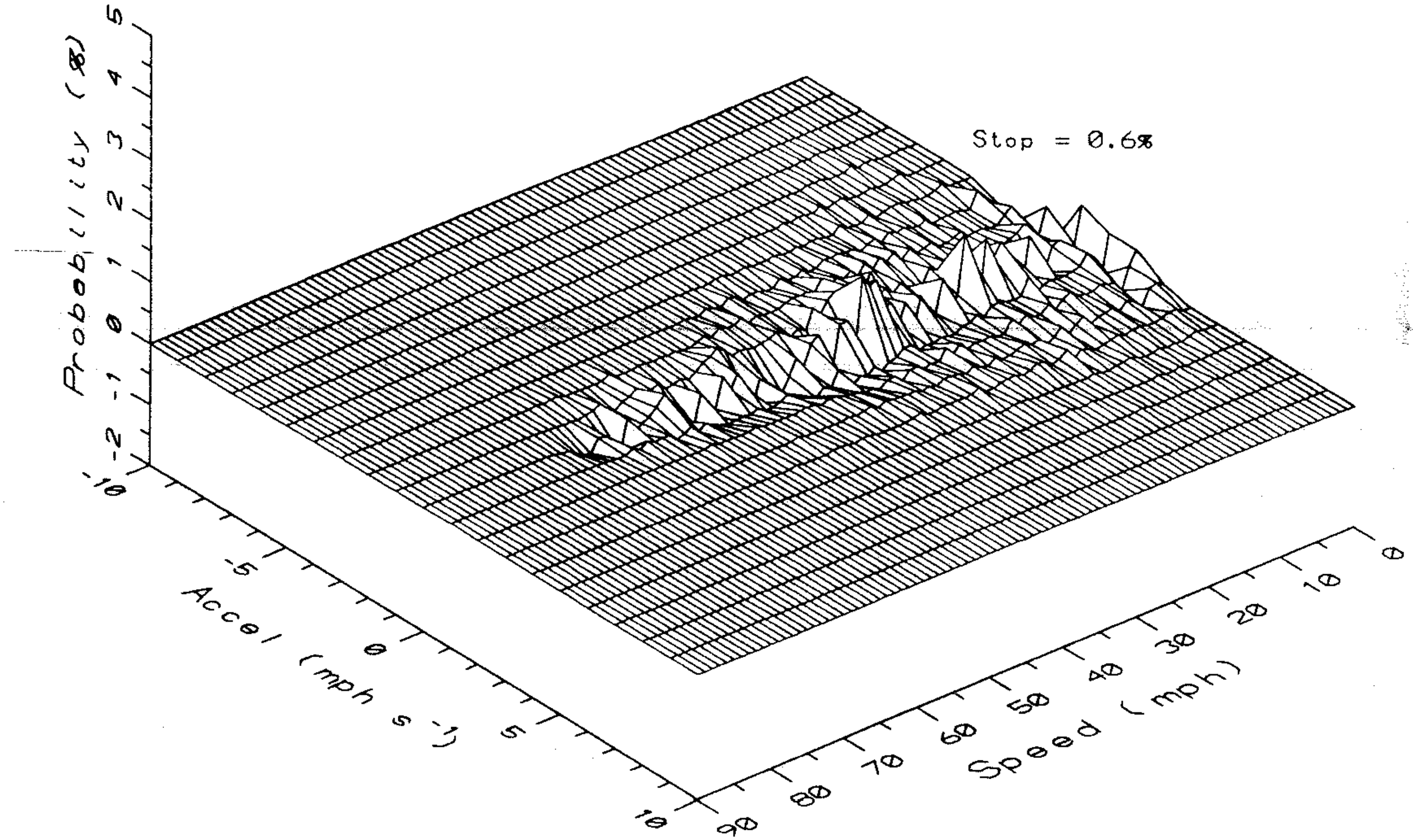

Figure 3.3.1.6 Average of the UCLA Freeway and Urban Dynamometer Driving Schedules minus average on-road freeway and urban conservative driving data.

dynamometer emissions tests. The bag and the one second emissions are given in Table 3.3.2.1, and the differences for CO, HC, and NO_x by pattern for each phase are shown in Figures 3.3.2.1, 3.3.2.2 and 3.3.2.3. Differences between bag and one second emission rates are common, with a normal variation between the bag and one second emission rates of "a few percent" (Society of Automotive Engineers, 1993). The average difference was only 3.3% for HC and 6.8% for NO_x, but was much higher for CO emission rates (27.7%). Possible causes of differences in emissions mass include sampling technique differences between bag and one second data, limitations in the accuracy of the one second analyzers at higher concentration ranges, and maximum concentration limitations in the one second analyzers.

3.3.3 Comparison of Bag Emissions to Emissions Certification Standards

The results from the emissions test conducted for the UCLA freeway, urban and acceleration dynamometer driving schedules, the 1:1 average of the UCLA freeway and urban driving schedule results, the FTP, the adjusted FTP (explained below) and the HFET are shown in Table 3.3.3.1 with the current California emissions standards. The FTP and HFET results are the average of three experiments each, only one experiment each was conducted for each of the UCLA cycles. The emission rates for each driving schedule in the table (except the HFET) are the weighted results from three-phase tests (cold start, hot running and warm start) using the weighting constants for the FTP (as shown in Equation 2.6.1).

The weighted emission rates for the UCLA freeway and urban driving schedules for all three pollutants were lower than the California emissions standards with the freeway and urban average equal to approximately half of the emission standards. The weighted emission rate of HC from the UCLA acceleration driving schedule was less than the emission standard, however the emission rate of NO_x was slightly higher than the standard, and the emission rate of CO was more than two times the standard.

All three of the UCLA patterns were longer than the FTP and therefore the cold and warm start emissions were averaged over a longer distance, reducing their relative

Table 3.3.2.1 Comparison of emissions data from summed one second emissions measurements and bag emissions measurements.

Bag &	HC, g/mi			CO, g/mi			NOx, g/mi		
Pattern	Bag	Hertz	% Difference	Bag	Hertz	% Difference	Bag	Hertz	% Difference
Cold Start:	**(Bag 1)**								
Freeway	0.450	0.433	3.9	8.113	0.899	88.9	0.099	0.087	11.9
Urban	0.621	0.549	11.6	11.390	3.842	66.3	0.258	0.189	26.9
Acceleration	0.511	0.544	-6.4	16.610	13.487	18.8	0.416	0.470	-13.0
FTP	0.783	0.736	6.0	11.277	6.119	45.7	0.328	0.261	20.5
FTP - Adjusted	0.414	0.392	5.3	5.769	3.271	43.3	0.186	0.148	20.4
Hot Running:	**(Bag 2)**								
Freeway	0.022	0.035	-59.3	0.210	0.199	5.1	0.207	0.187	9.8
Urban	0.078	0.086	-10.2	0.694	0.518	25.4	0.232	0.181	22.2
Acceleration	0.228	0.216	5.0	14.850	10.203	31.3	0.437	0.480	-9.9
FTP	0.071	0.073	-2.4	0.641	0.621	3.1	0.053	0.043	19.8
HFET	0.022	0.025	-16.0	0.071	0.066	7.2	0.352	0.309	12.3
Warm Start:	**(Bag 3)**								
Freeway	0.058	0.061	-4.3	0.746	0.679	9.0	0.253	0.243	4.0
Urban	0.132	0.120	9.4	2.108	1.643	22.1	0.256	0.224	12.5
Acceleration	0.210	0.207	1.2	13.120	11.742	10.5	0.392	0.514	-31.1
FTP	0.087	0.071	18.9	0.437	0.321	26.6	0.316	0.308	2.6
FTP - Adjusted	0.079	0.072	9.0	0.543	0.476	12.2	0.180	0.170	5.2
Weighted Averages:	**((Bag1*0.43)+(Bag 2) + (Bag 3*0.57))/3**								
Freeway	0.124	0.128	-2.8	2.062	0.486	76.4	0.197	0.181	7.9
Urban	0.210	0.195	7.2	3.397	1.553	54.3	0.244	0.195	20.3
Freeway/Urban Average	0.167	0.161	3.5	2.729	1.020	62.6	0.221	0.188	14.8
Acceleration	0.284	0.284	-0.2	14.735	11.348	23.0	0.420	0.488	-16.2
FTP	0.229	0.215	6.1	2.870	1.718	40.1	0.187	0.165	11.8
FTP - Adjusted	0.147	0.141	4.0	1.715	1.150	33.0	0.118	0.102	13.6
1989-92 Standard	0.410	0.410	0.0	7.000	7.000	0.0	0.400	0.400	0.0
Error Analysis:	**Note: No weighted or adjusted data included, only originally collected data.**								
Average % Difference			-3.3			27.7			6.8
Standard Deviation			19.3			25.6			16.4

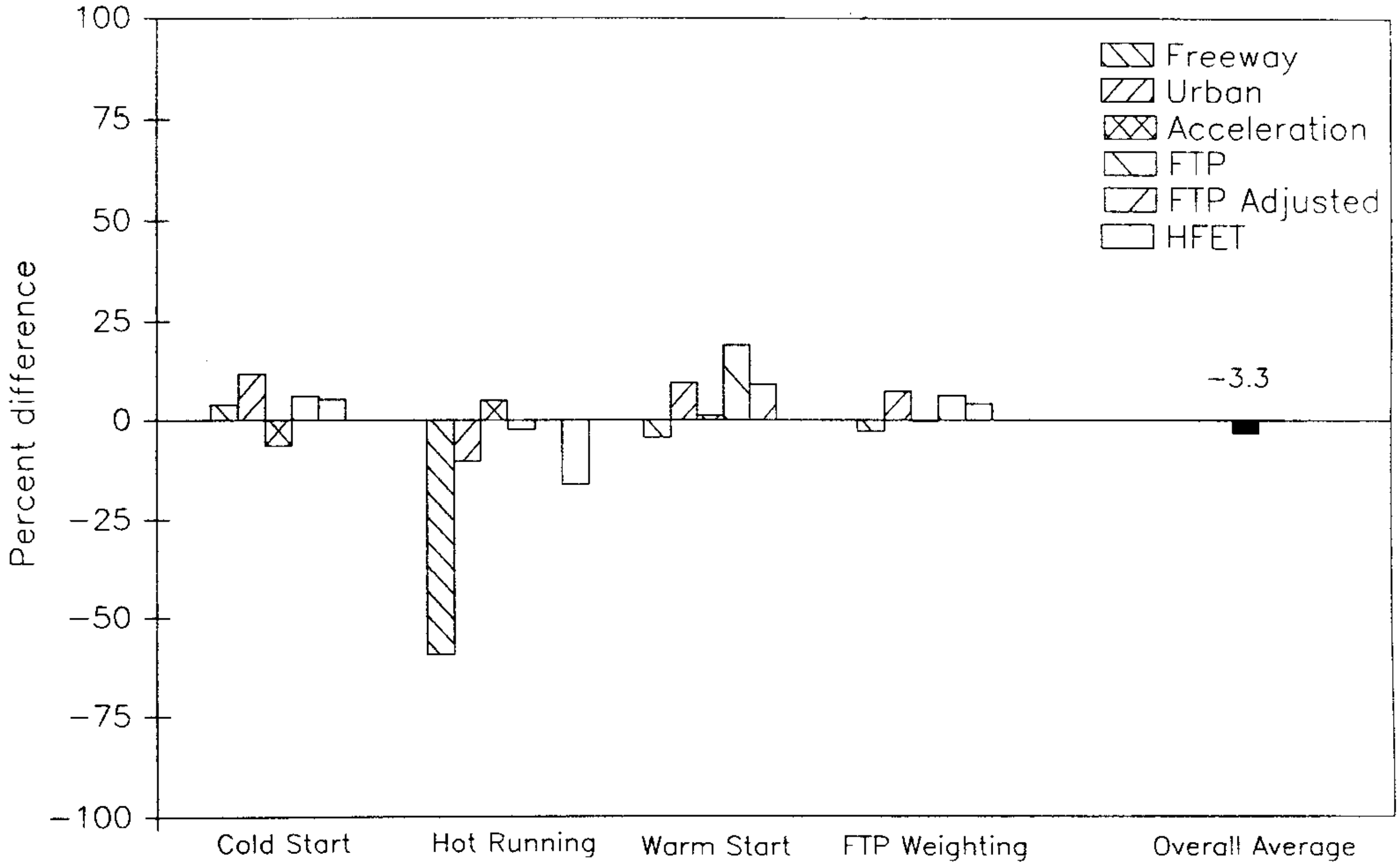

Figure 3.3.2.1 Differences between bag calculated and hertz calculated emission rate data for HC by test schedule.

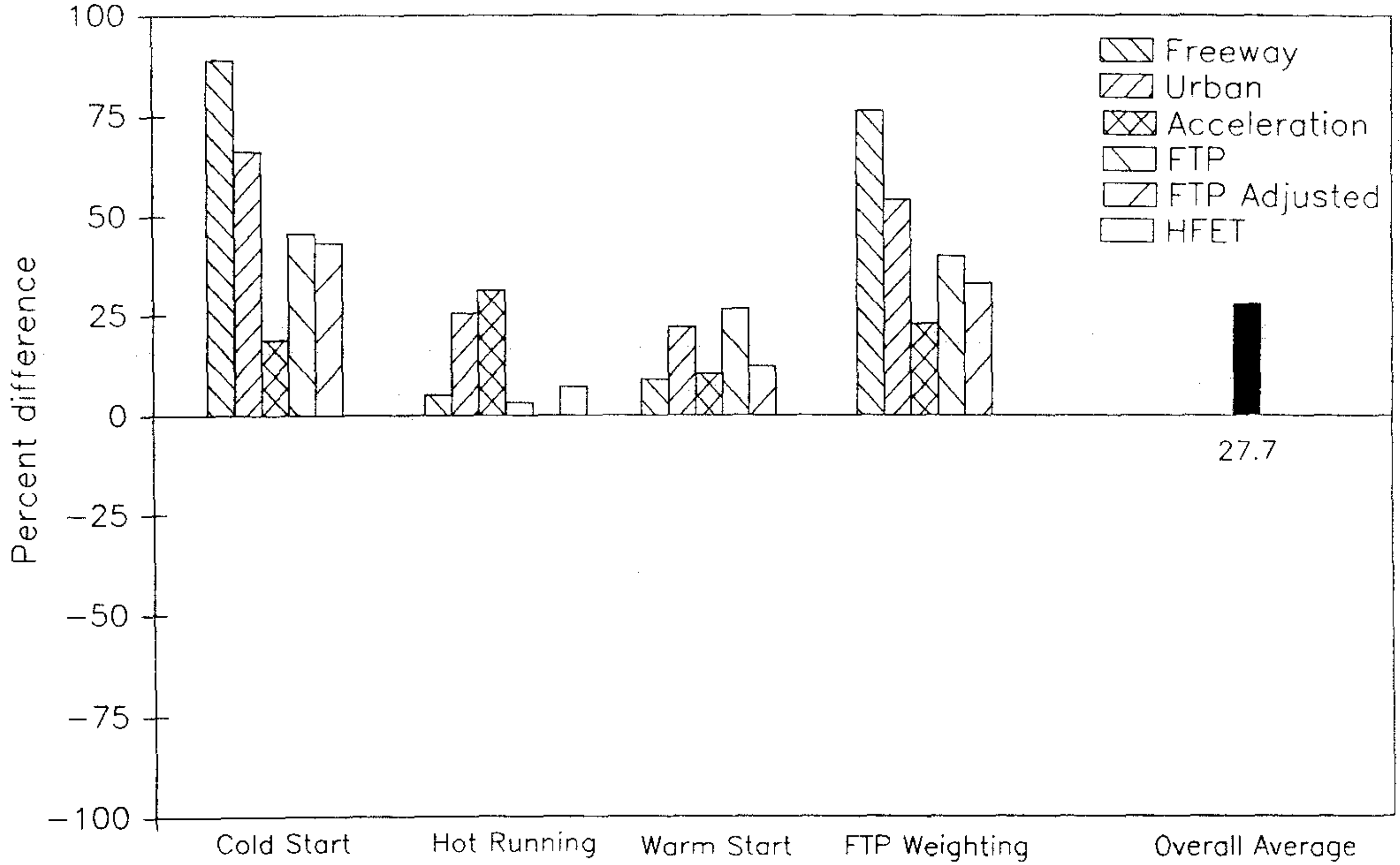

Figure 3.3.2.2 Differences between bag calculated and hertz calculated emission rate data for CO by test schedule.

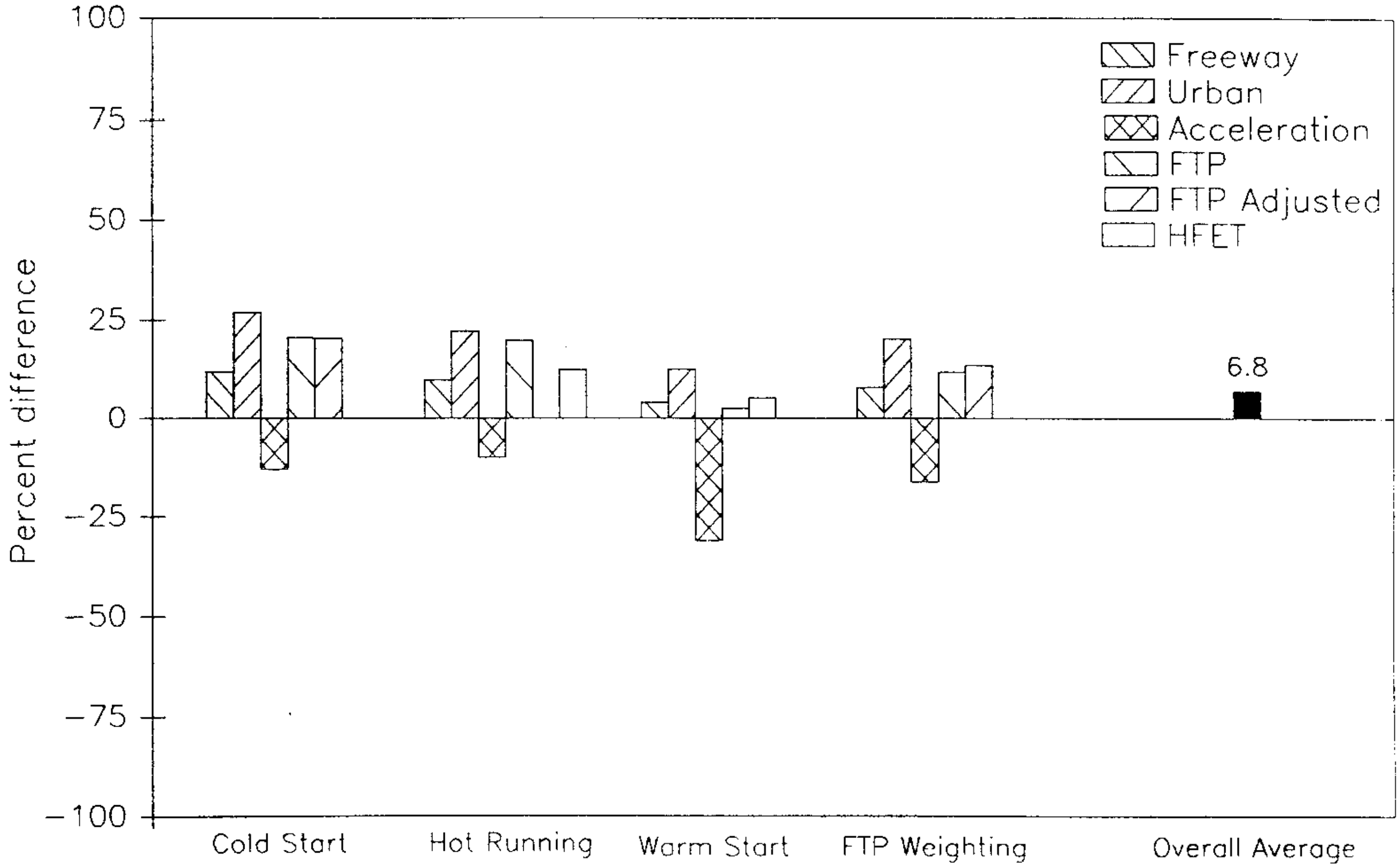

Figure 3.3.2.3 **Differences between bag calculated and hertz calculated emission rate data for NO_x by test schedule.**

Table 3.3.3.1 Total distance and weighted emission rates from the UCLA Dynamometer Driving Schedules, the FTP and HFET.

Pattern	Distance miles	HC g mi^{-1}	CO g mi^{-1}	NO_x g mi^{-1}
California Standards		0.410	7.000	0.400
FTP (average)	3.59	0.229	2.870	0.187
Adjusted FTP	7.26	0.147	1.715	0.118
HFET (average)	9.98	0.022	0.071	0.352
UCLA Freeway	12.53	0.124	2.062	0.197
UCLA Urban	7.47	0.210	3.397	0.244
UCLA F/U Average	10.00	0.167	2.729	0.221
UCLA Acceleration	10.92	0.284	14.735	0.420

weighting. This prevented direct comparison of the emissions rates from the UCLA driving schedules to the FTP and the HFET. To allow for comparison, the data from bag 2 were added to the ends of the bag 1 and 3 data sets and then the data sets were reanalyzed. This process increased the length of the pattern from to 3.59 to 7.26 miles, close to the distance of the UCLA urban pattern. The result of a longer test pattern can be seen by comparing the emissions from the FTP and the adjusted FTP in which the emission rates for all three pollutants decreased approximately a third.

The emission rates for the UCLA freeway dynamometer driving schedule were higher than the adjusted FTP for CO and NO_x, but lower for HC. The emission rates for the UCLA urban dynamometer driving schedule were all greater than the emission rates of the adjusted FTP. The emission rates from the equal weighting of the freeway and urban data were higher than the adjusted FTP for all three pollutants, but compared to the standard FTP only the emission rate for NO_x was higher.

3.3.4 Frequency and Emission Rates of Open Loop Operation During the Dynamometer Emission Tests

The speed, lambda of the exhaust gas and the open loop flag of the vehicle during bags 1 and 2 of the FTP are shown in Figure 3.3.4.1a. At the beginning of the test, the vehicle operated rich open loop during start for approximately 50 seconds and remained closed loop for the duration of the test. The associated emission rates of HC, CO and NO_x during bags 1 and 2 are shown in Figure 3.3.4.1b. As can be seen from the plots, there were three high HC peaks at the beginning of the test which corresponded to the three accelerations (one from 0 to 22 mph and two 15 to 22 mph) in the first "hill" of the FTP. After the vehicle went closed loop, HC emissions were at the detection level of the instruments (0.001 g s^{-1}) with small peaks up to 0.005 g s^{-1} which tapered off over time.

CO emissions were only significant at the beginning of the test. The maximum emission rate of CO was only 0.154 g s^{-1}. The emission of NO_x was also low at the beginning of the test. Because the formation of NO_x is lowest during rich operation and at low temperatures, NO_x emissions during start are not expected to be high. The emissions during start are attributed to the catalyst being cold and not efficient for NO_x yet. The maximum emission rate of NO_x (0.0285 g s^{-1}) was approximately 200 seconds into the test and occurred during highest speed acceleration of the test.

During the driving of the UCLA freeway dynamometer driving cycle, no open loop operation was observed which was not related to start. The speed, lambda of the exhaust gas and the open loop flag of the vehicle during the cold start test are shown in Figure 3.3.4.2a, and the associated emission rates of HC, CO and NO_x are shown in Figure 3.3.4.2b. As in the FTP test, the vehicle operated rich open loop at start for approximately 50 seconds and had high HC emissions. The HC emissions during this test were higher than for the FTP because driving of the vehicle began closer to the start and began with a hard acceleration up to 60 mph. CO and NO_x emissions during the rich open loop operation at start were relatively the same as for the FTP. The only other emission peak was a NO_x peak at approximately 1260 seconds which was related to a high speed hard acceleration although the air fuel ratio did not appear to deviate from

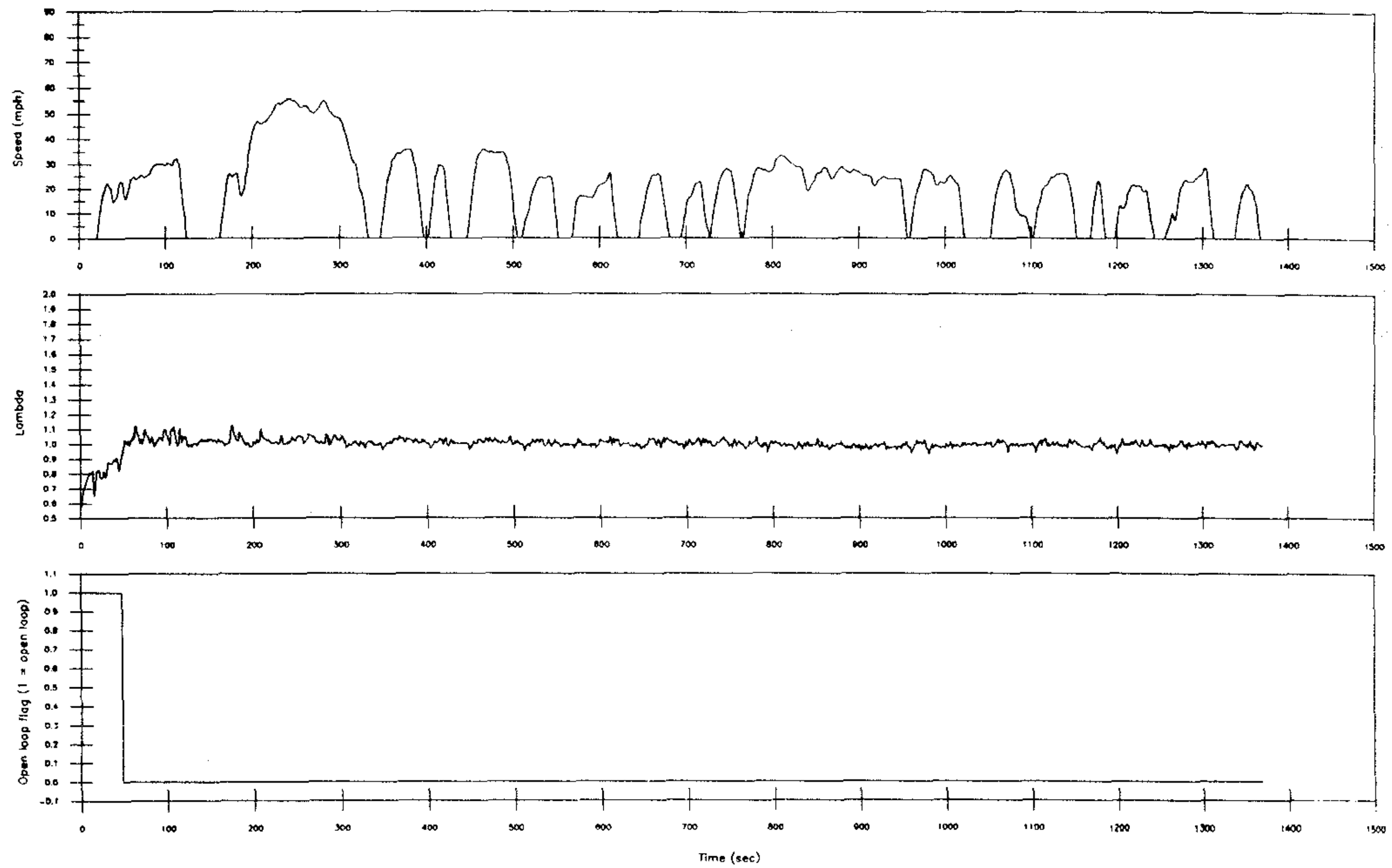

Figure 3.3.4.1a Speed, lambda, and open loop flag during driving of the FTP, cold start and hot running bags.

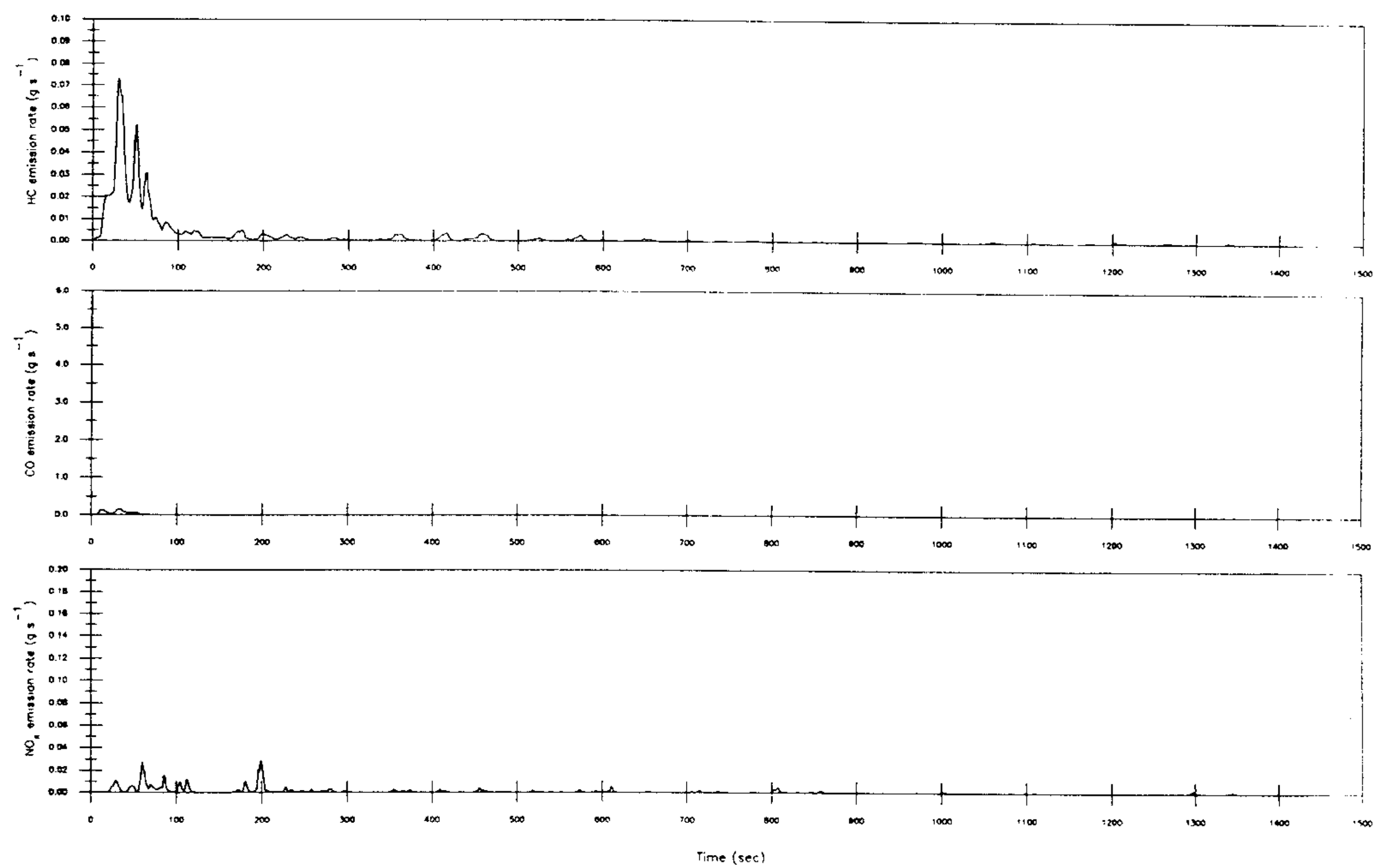

Figure 3.3.4.1b Emission rates of HC, CO, and NO_x during driving of the FTP, cold start and hot running bags.

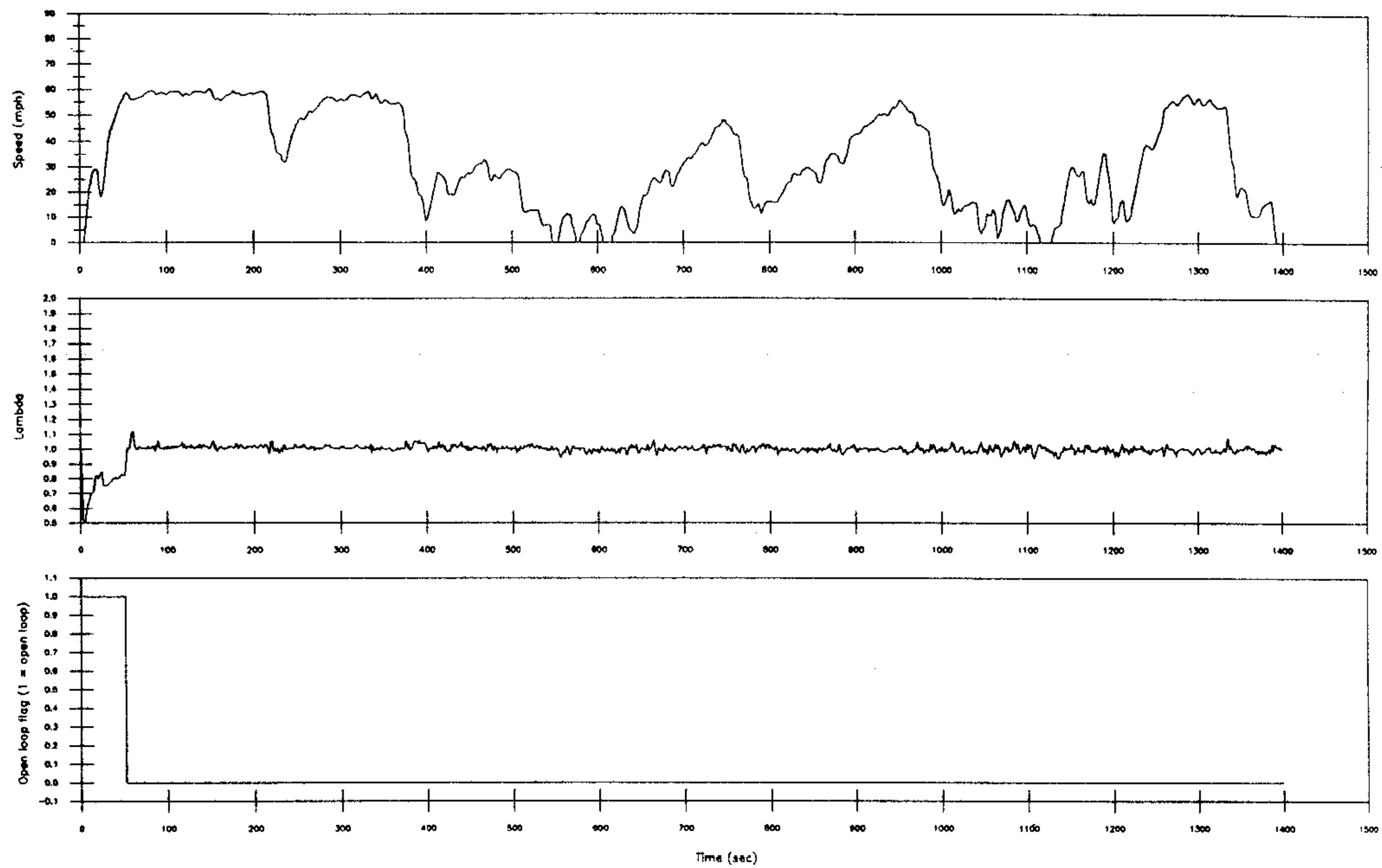

Figure 3.3.4.2a Speed, lambda, and open loop flag during driving of the UCLA Freeway Dynamometer Driving Schedule, cold start bag.

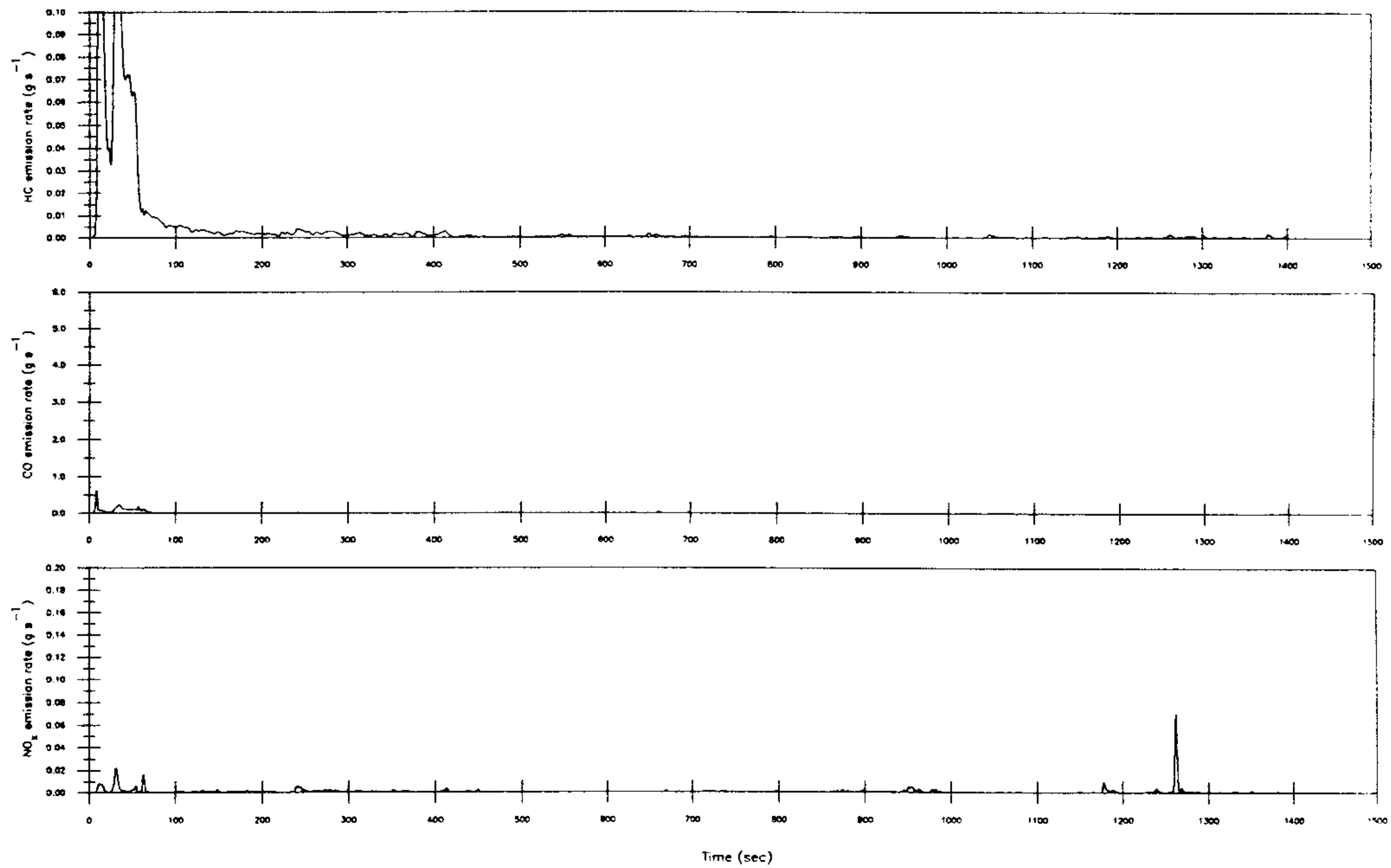

Figure 3.3.4.2b Emission rates of HC, CO, and NO_x during driving of the UCLA Freeway Dynamometer Driving Schedule, cold start bag.

stoichiometry.

During the driving of the UCLA urban dynamometer driving cycle as a cold start, there were three rich open loop events not related to start (Figure 3.3.4.3a). The emissions peaks of all three pollutants during the rich open loop events can be seen in Figure 3.3.4.3b at approximately 120, 940 and 1200 seconds. The duration of the events were 3, 2, and 3 seconds (from left to right), with the highest emissions of all three pollutants associated with the first rich open loop event (at 120 seconds). The air-to-fuel ratio during all three of these events can be seen in Figure 3.3.4.3a to be rich, outside of the minimum for closed loop operation. The emissions from the first rich open loop event may be the largest because it occurred near to start and the catalyst may not have been fully warmed up and therefore the efficiency of the catalyst was not high enough to remove the pollutants (catalyst light off is described below). The second event (at 940 seconds) was shorter in duration and produced less emissions than the other two events.

The emission rates of HC, CO and NO_x during lean and rich open loop operation were determined from the UCLA acceleration pattern emission tests because they were the only tests with any lean open loop operation and because they had a relatively high frequency of rich open loop operation compared to the other test patterns.

The speed, lambda of the exhaust gas and the open loop flag of the vehicle during the cold start test, hot running test (no start), and the warm start test for the UCLA acceleration pattern are shown in Figures 3.3.4.4a, 3.3.4.5a and 3.3.4.6a respectively. The load, exhaust gas temperature, and catalyst temperature for the three phases are shown in Figures 3.3.4.4b, 3.3.4.5b and 3.3.4.6b, and the associated emission rates of HC, CO and NO_x are shown in Figures 3.3.4.4c, 3.3.4.5c and 3.3.4.6c. To aid in determination of the light off temperature of the catalyst (the point at which the catalyst became 50% efficient for conversion) the catalyst efficiencies for HC, CO, and NO_x over the duration of the three phases of the test are plotted in Figures 3.3.4.4d, 3.3.4.5d and 3.3.4.6d.

For the cold start experiment, there were 11 rich open loop events (excluding start) ranging from 2 to 5 seconds in duration and 4 lean open loop events lasting either 1 or 2 seconds. For the hot running experiment the lean open loop events were the same as

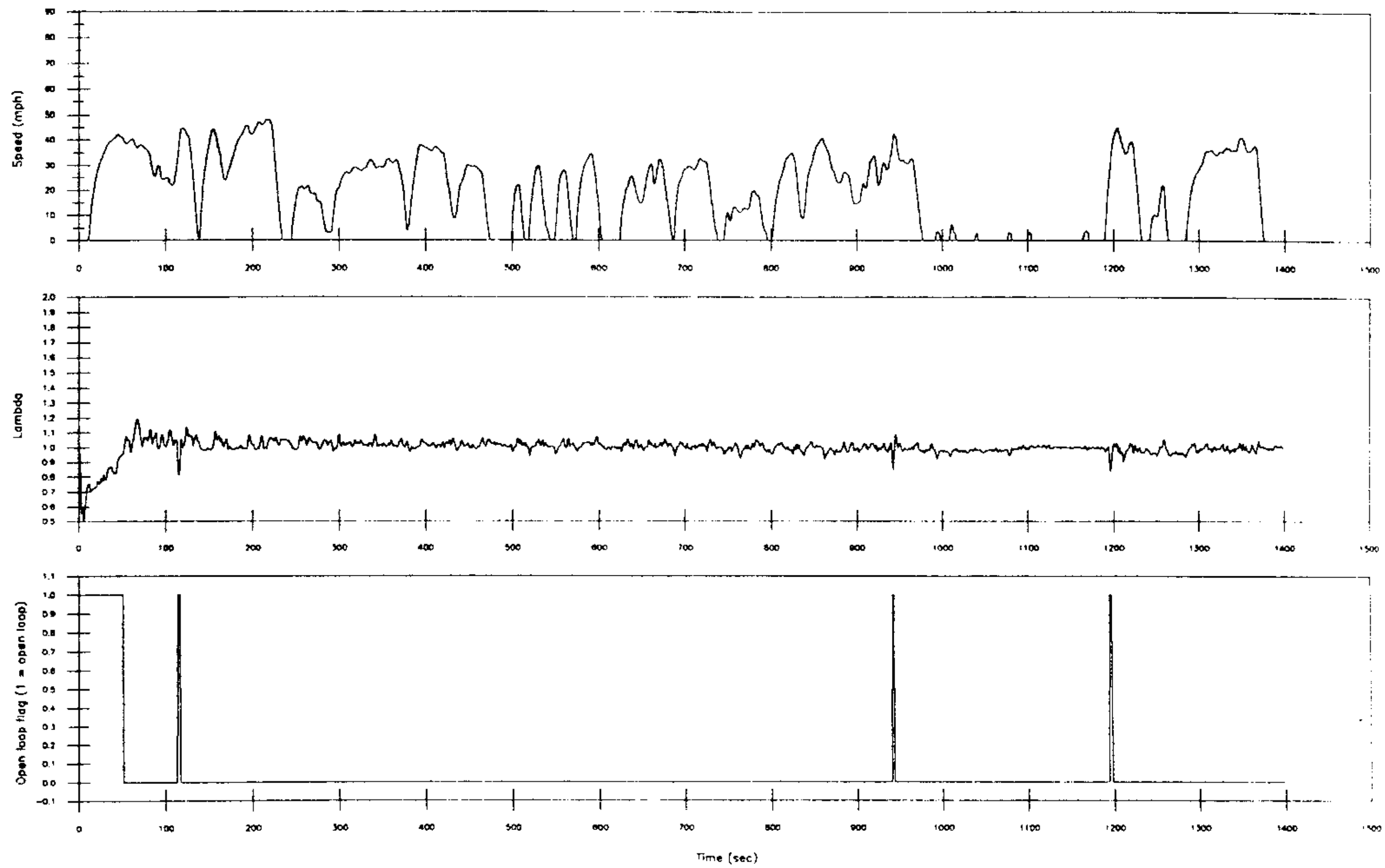

Figure 3.3.4.3a Speed, lambda, and open loop flag during driving of the UCLA Urban Dynamometer Driving Schedule, cold start bag.

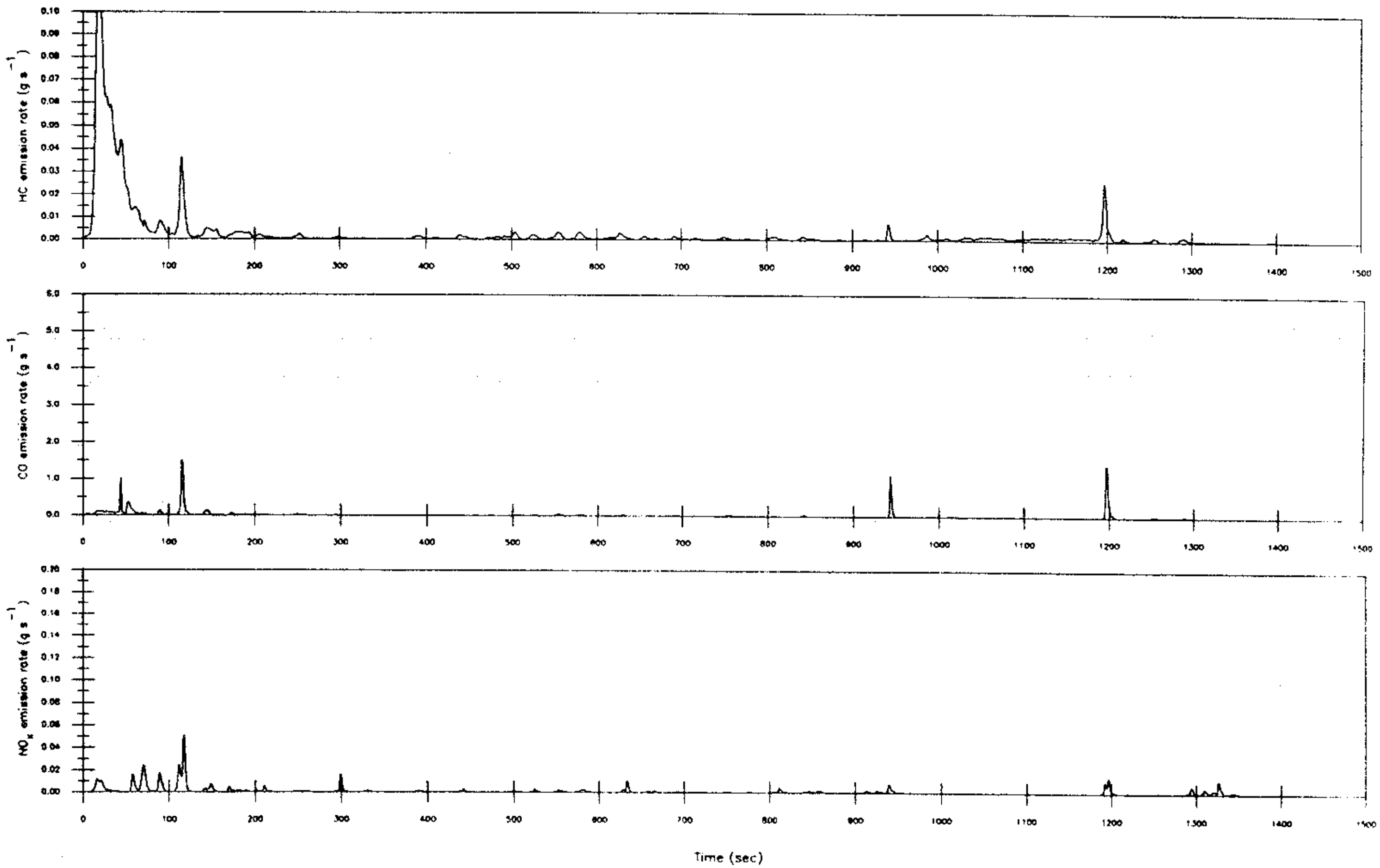

Figure 3.3.4.3b Emission rates of HC, CO, and NO_x during driving of the UCLA Urban Dynamometer Driving Schedule, cold start bag.

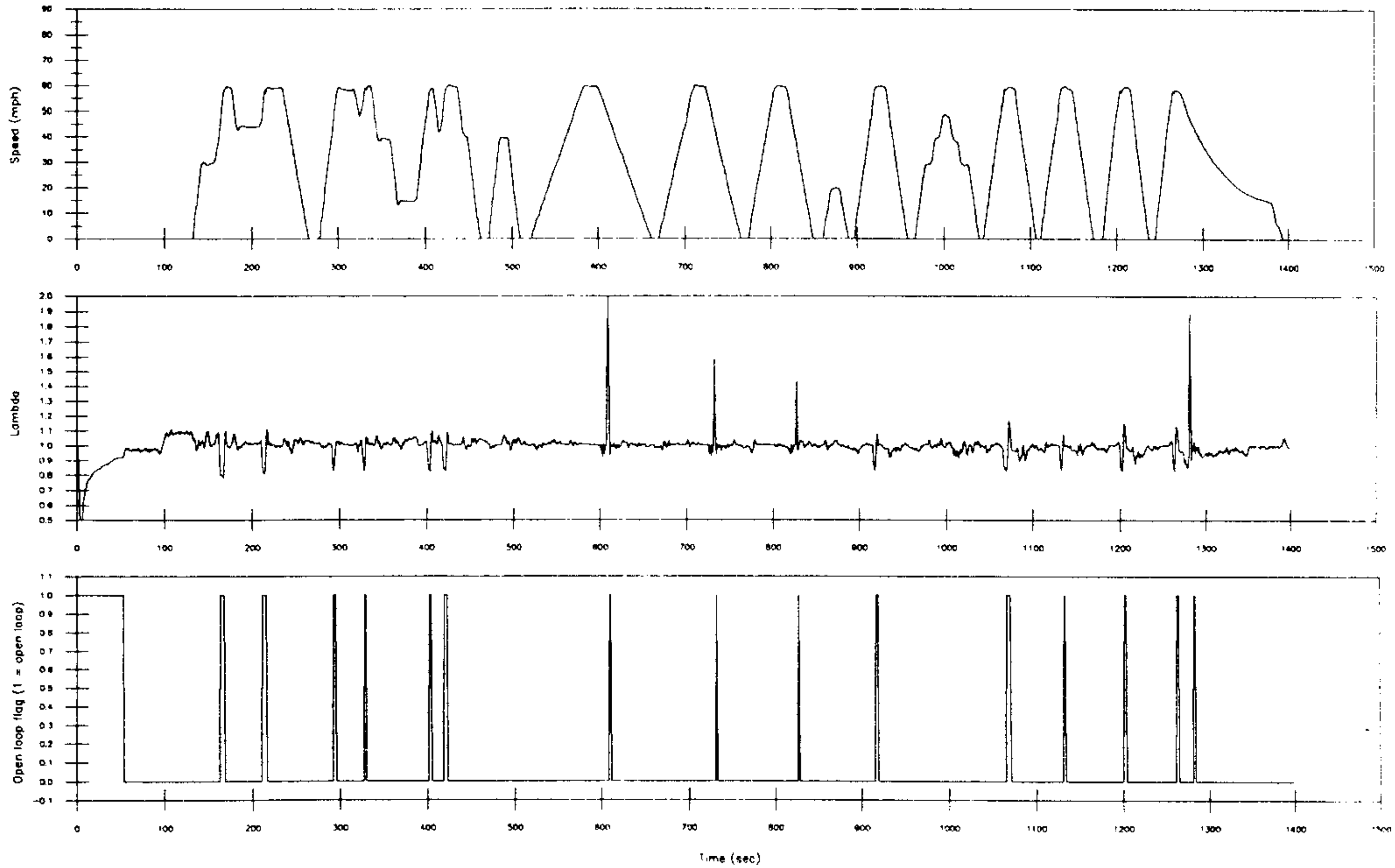

Figure 3.3.4.4a Speed, lambda, and open loop flag during driving of the UCLA Acceleration Dynamometer Driving Schedule, cold start bag.

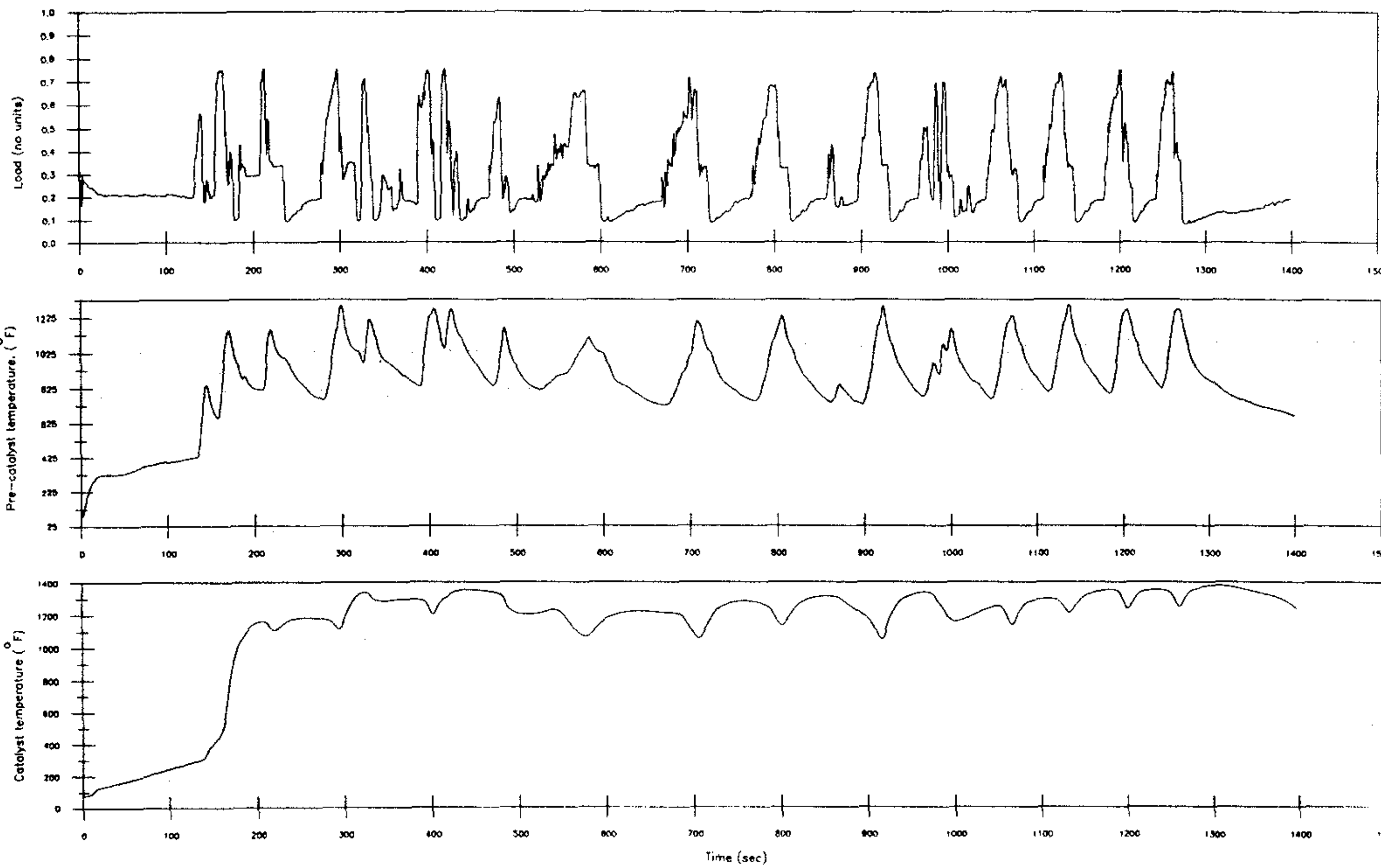

Figure 3.3.4.4b Load, exhaust gas temperature, and catalyst temperature during driving of the UCLA Acceleration Dynamometer Driving Schedule, cold start bag.

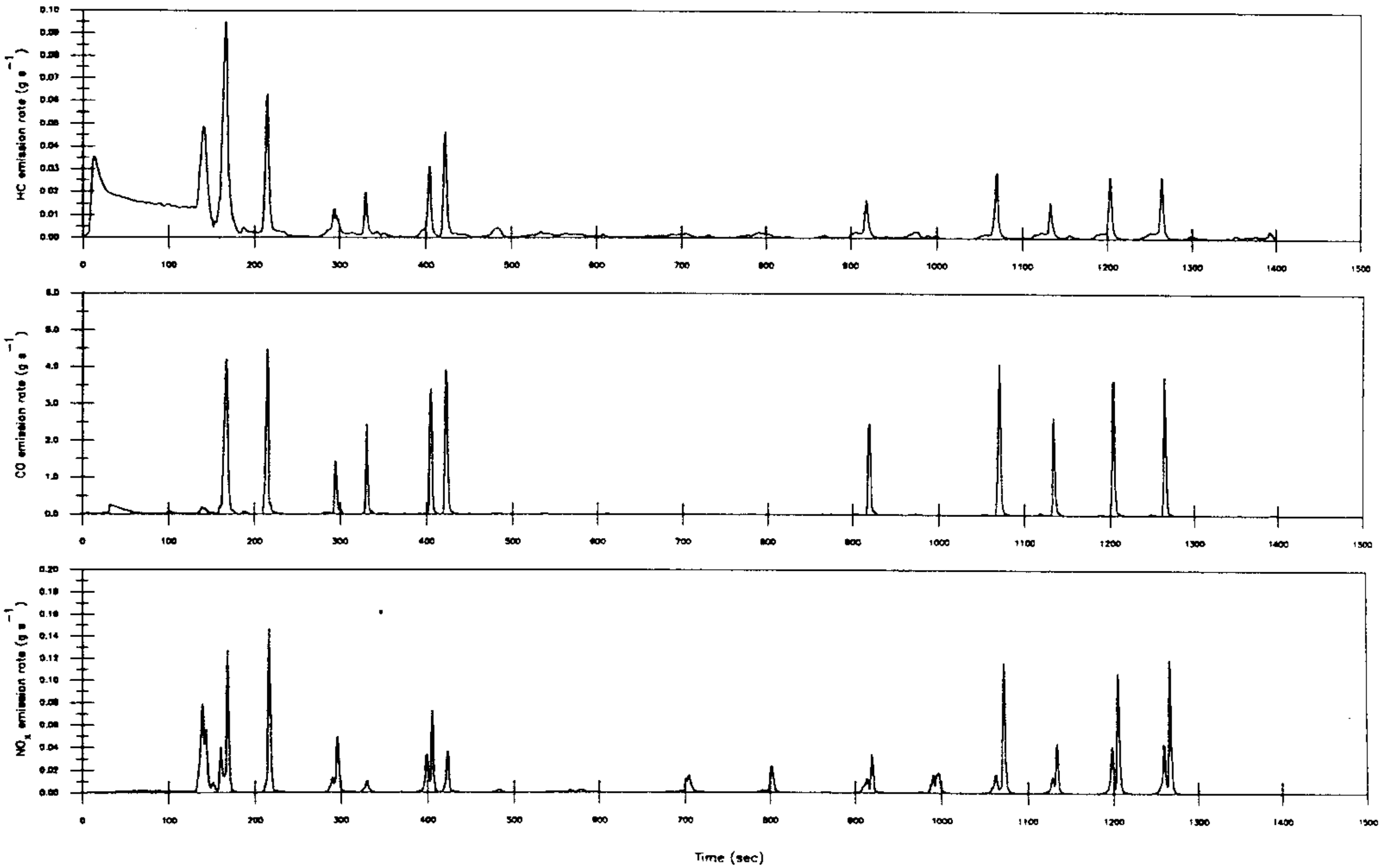

Figure 3.3.4.4c Emission rates of HC, CO, and NO_x during driving of the UCLA Acceleration Dynamometer Driving Schedule, cold start bag.

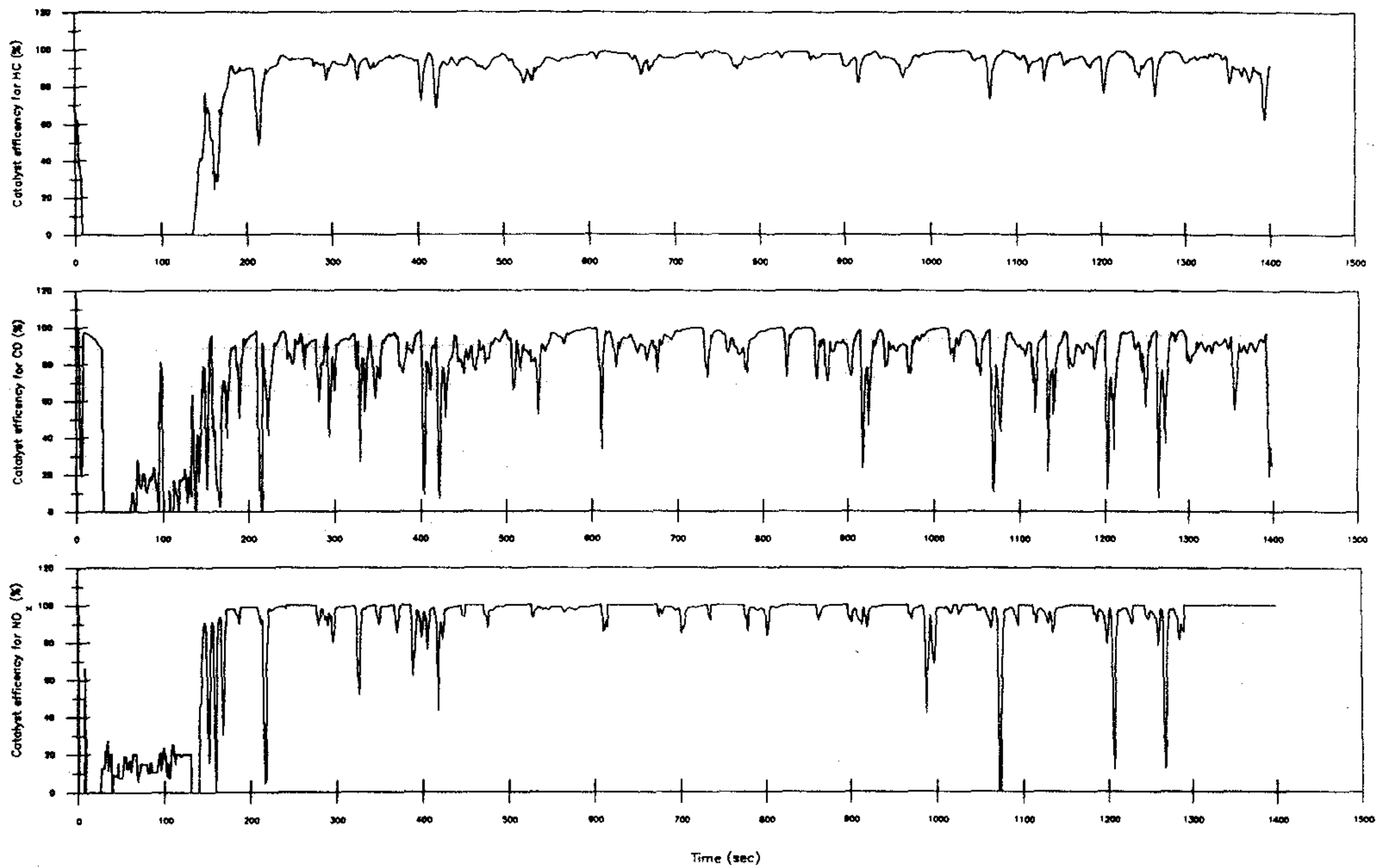

Figure 3.3.4.4d Catalyst efficiency for HC, CO, and NO_x during driving of the UCLA Acceleration Dynamometer Driving Schedule, cold start bag.

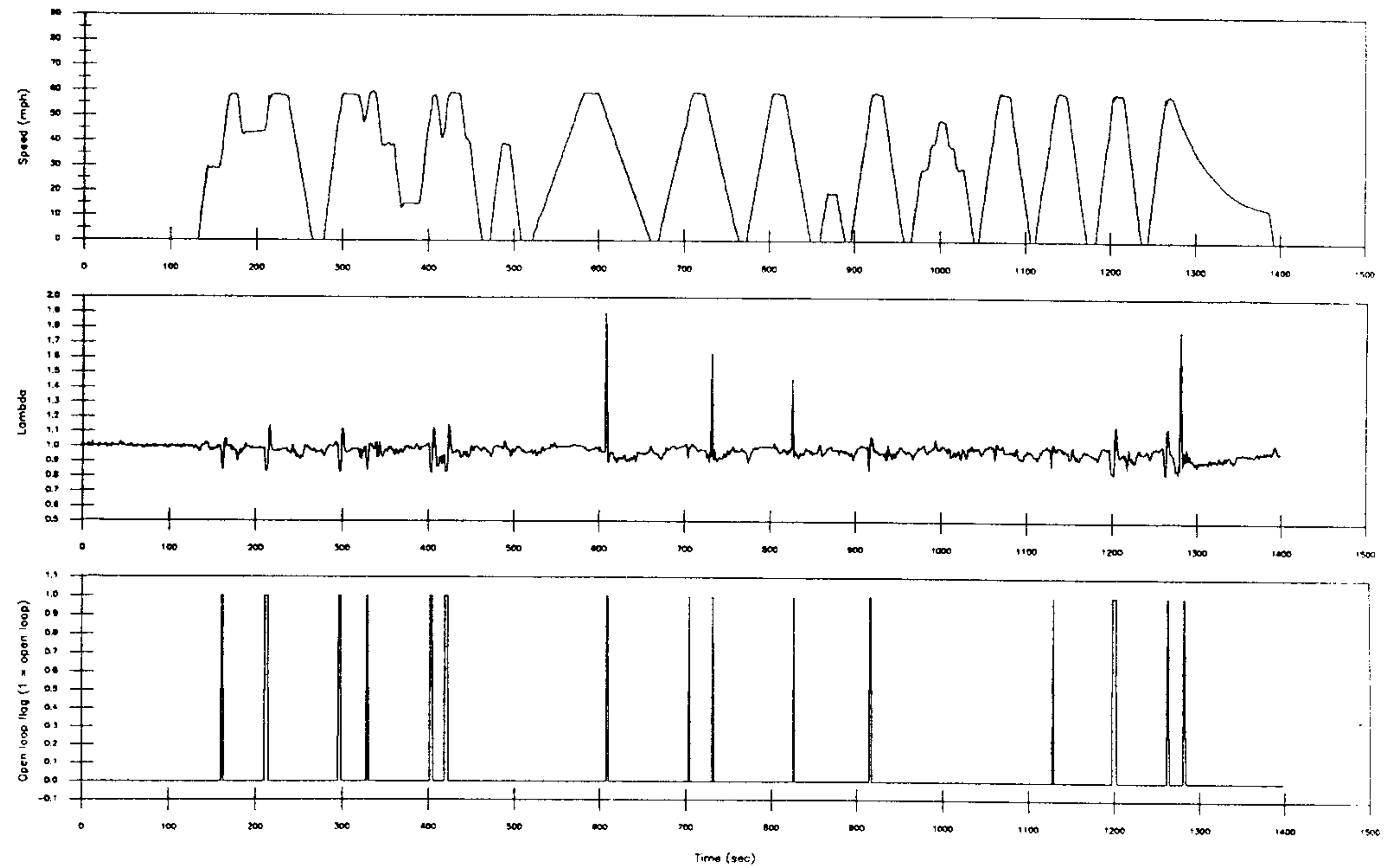

Figure 3.3.4.5a Speed, lambda, and open loop flag during driving of the UCLA Acceleration Dynamometer Driving Schedule, hot running bag.

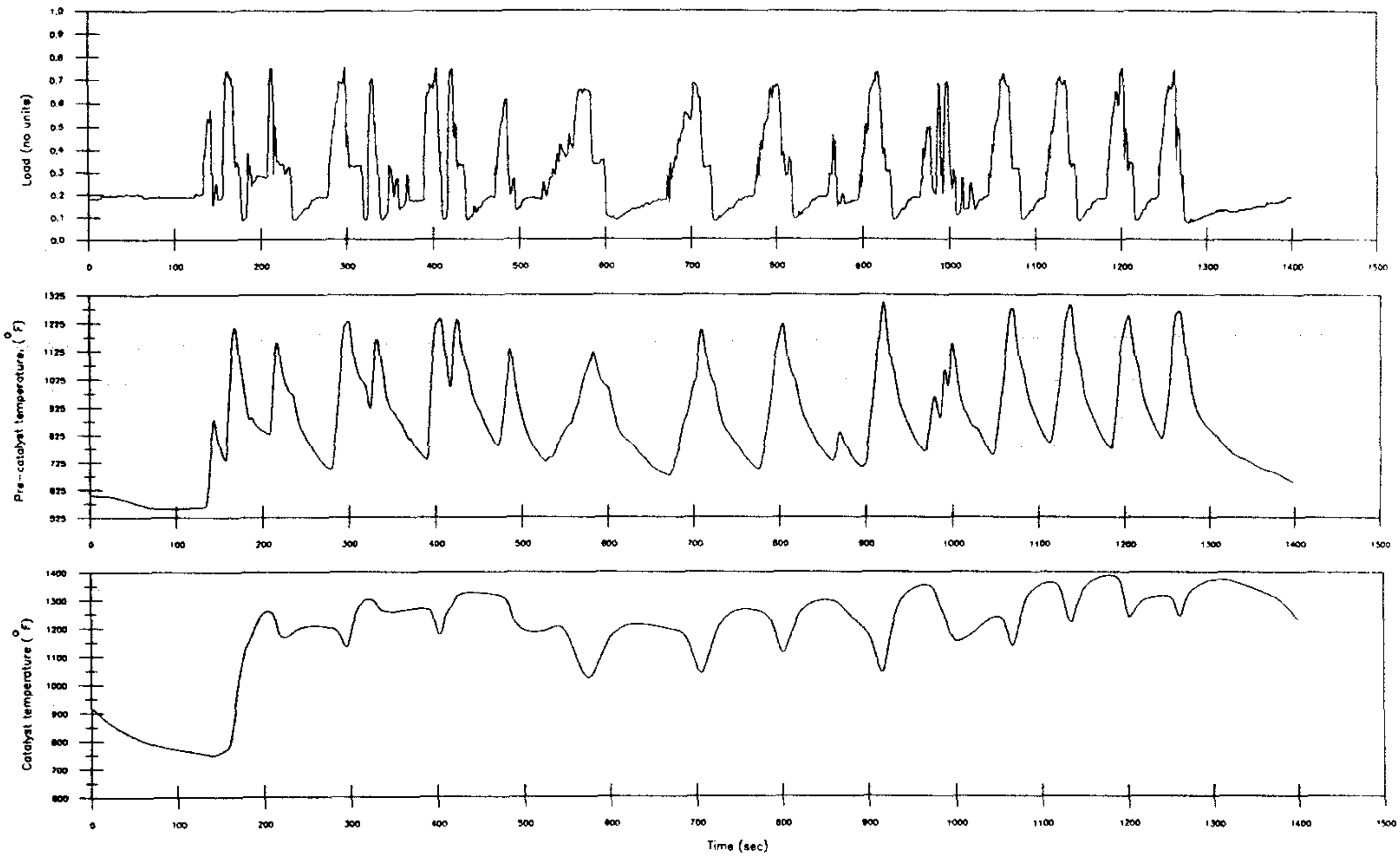

Figure 3.3.4.5b Load, exhaust gas temperature, and catalyst temperature during driving of the UCLA Acceleration Dynamometer Driving Schedule, hot running bag.

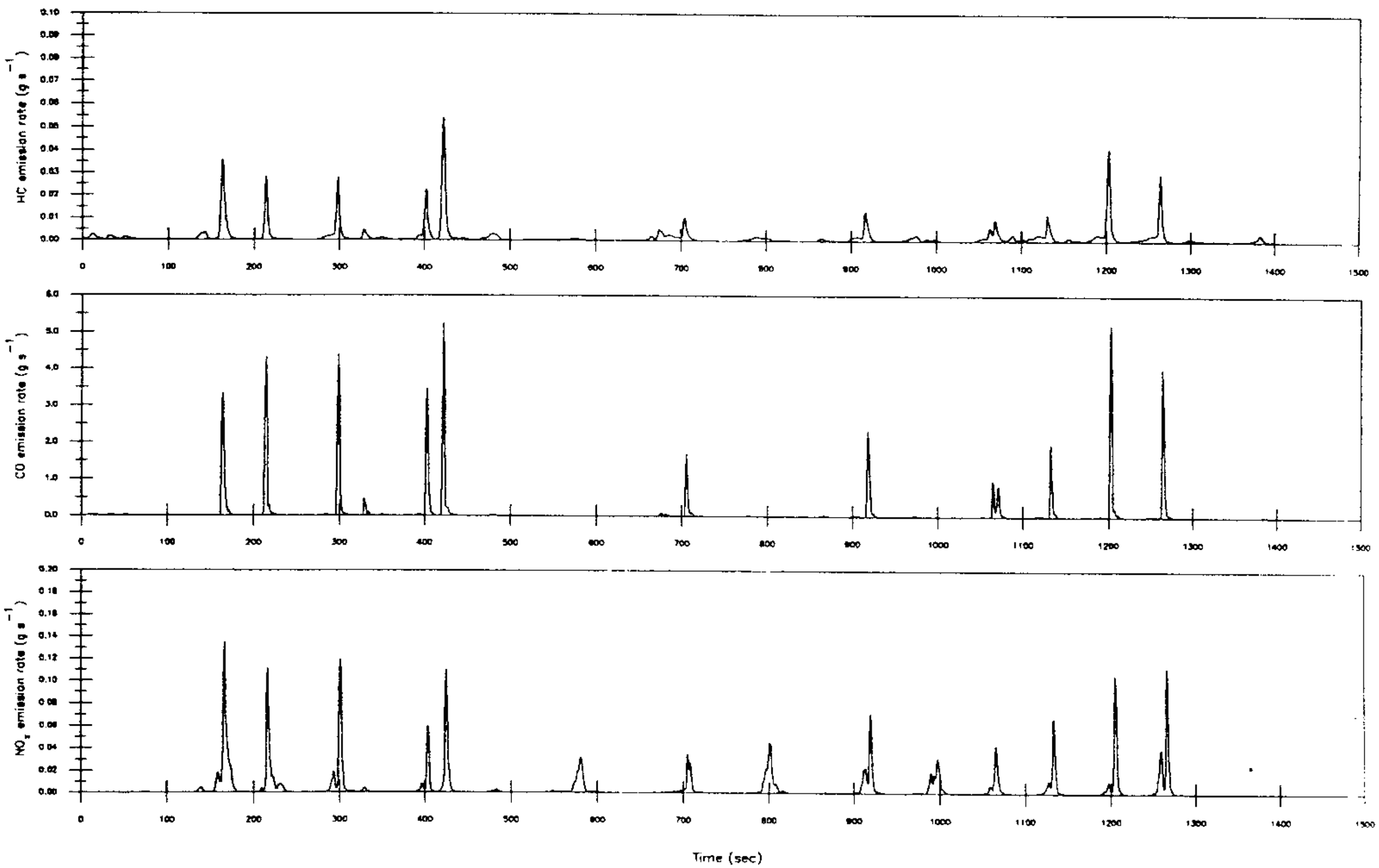

Figure 3.3.4.5c Emission rates of HC, CO, and NO_x during driving of the UCLA Acceleration Dynamometer Driving Schedule, hot running bag.

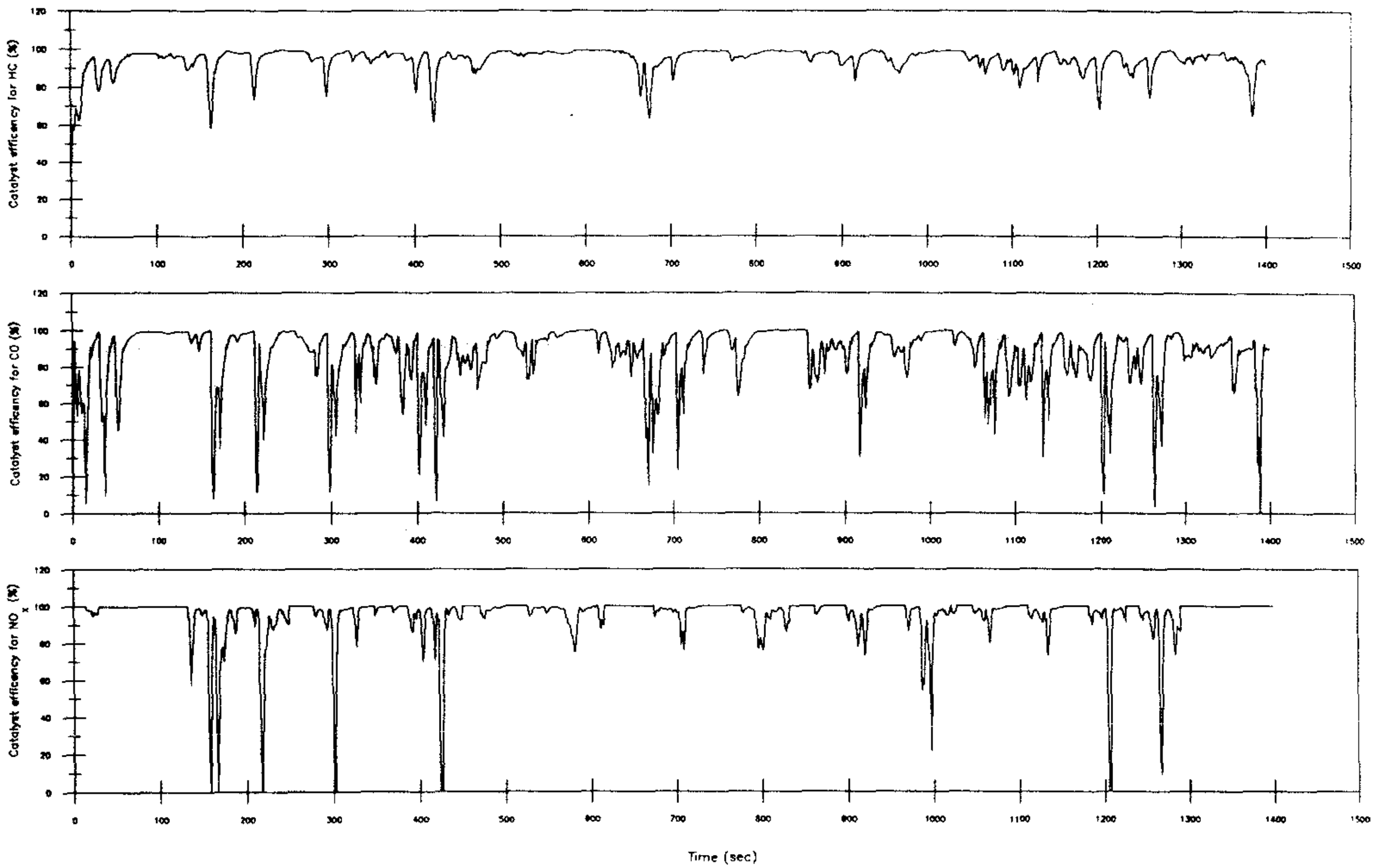

Figure 3.3.4.5d Catalyst efficiency for HC, CO, and NO_x during driving of the UCLA Acceleration Dynamometer Driving Schedule, hot running bag.

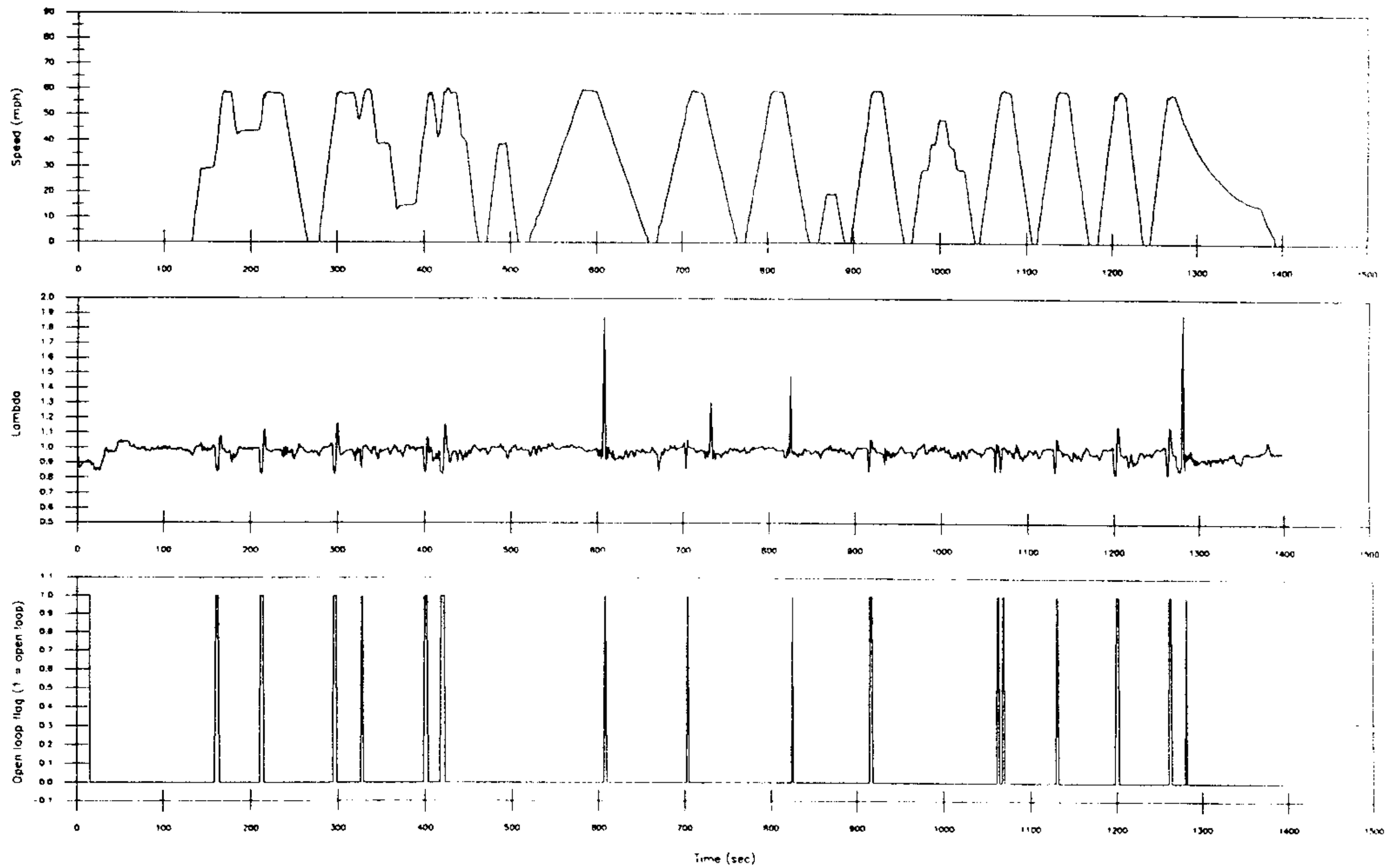

Figure 3.3.4.6a Speed, lambda, and open loop flag during driving of the UCLA Acceleration Dynamometer Driving Schedule, warm start bag.

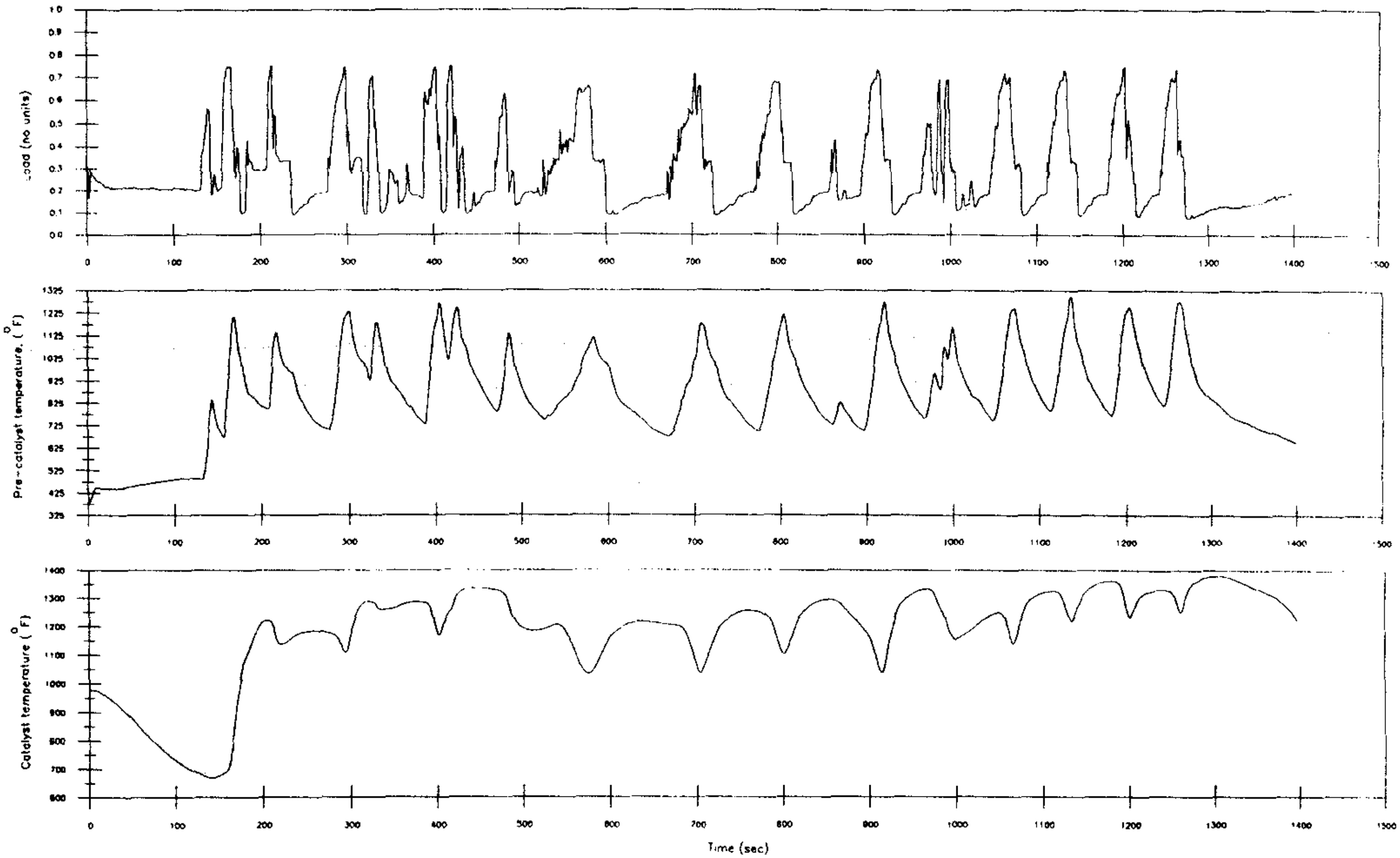

Figure 3.3.4.6b Load, exhaust gas temperature, and catalyst temperature during driving of the UCLA Acceleration Dynamometer Driving Schedule, warm start bag.

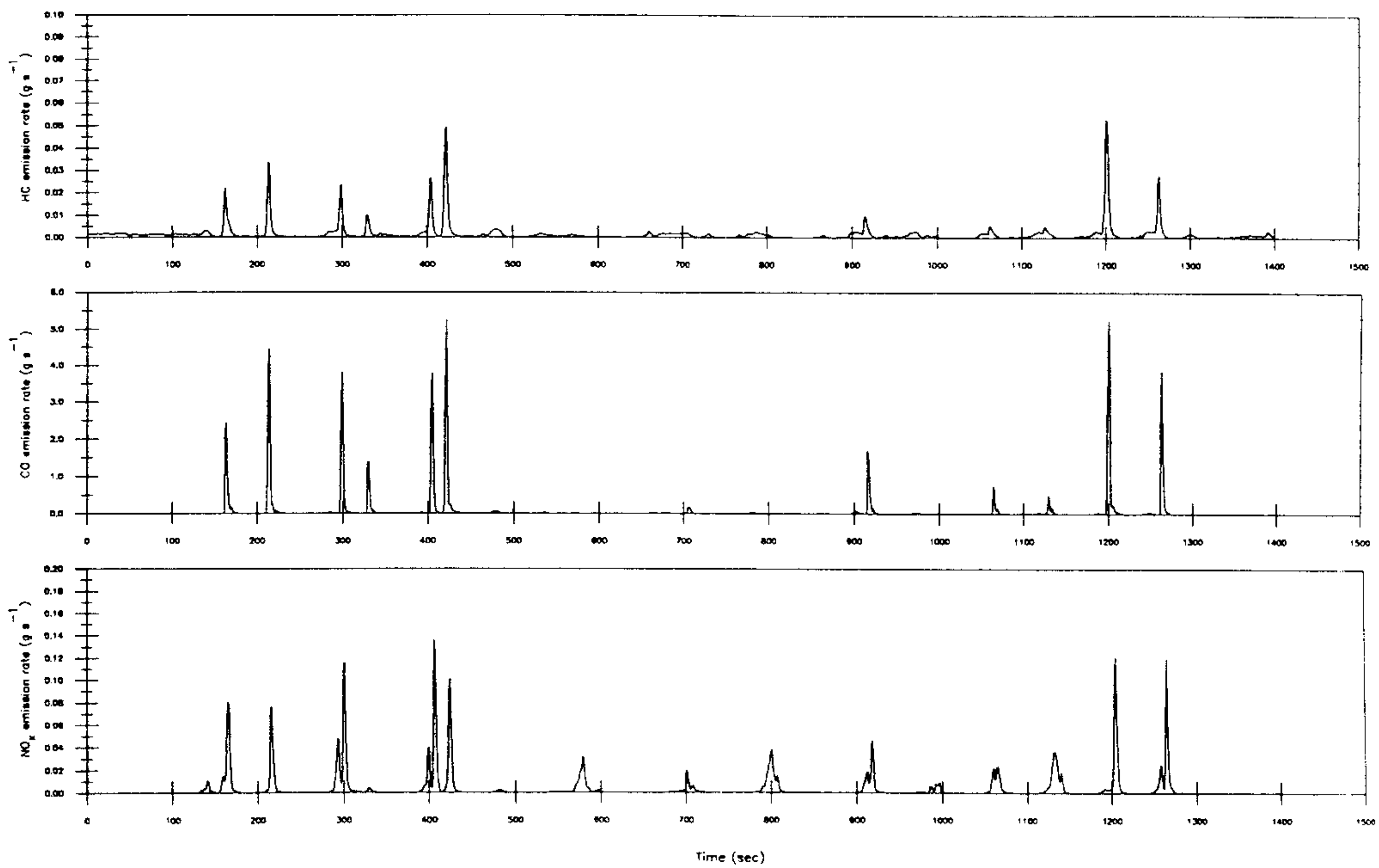

Figure 3.3.4.6c Emission rates of HC, CO, and NO_x during driving of the UCLA Acceleration Dynamometer Driving Schedule, warm start bag.

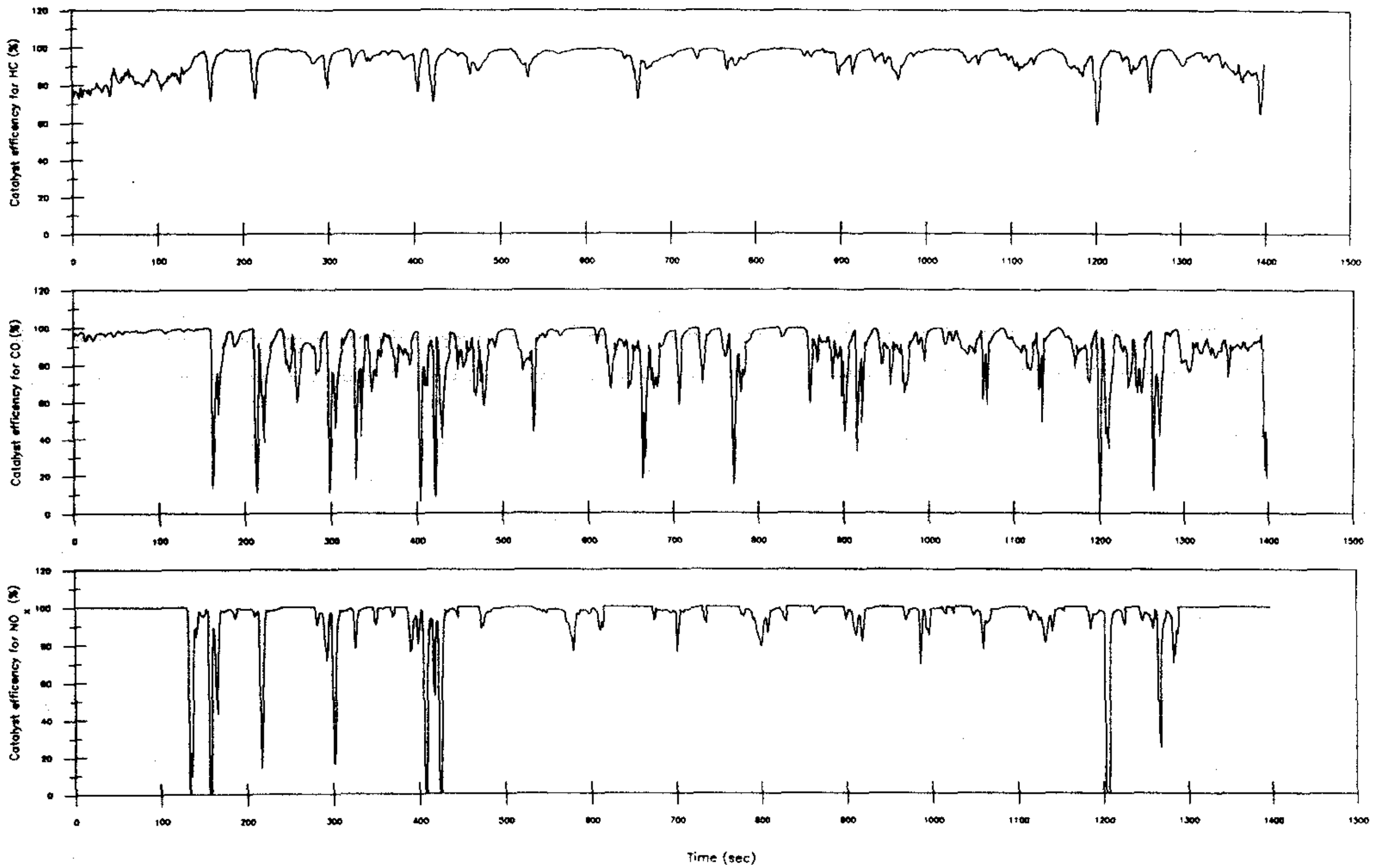

Figure 3.3.4.6d Catalyst efficiency for HC, CO, and NO_x during driving of the UCLA Acceleration Dynamometer Driving Schedule, warm start bag.

for the cold start test and there were also 11 rich open loop events (ranging from 1 to 5 seconds) but one occurred at a different time than in the cold start test. For the cold start test there was a rich open loop event at 1070 seconds during a hard acceleration which was not in the hot running test, and conversely, there was a rich open loop event at 700 seconds in the hot running test which was not in the cold start test.

For the warm start test of the UCLA acceleration pattern, there were 13 rich open loop events (excluding start) also ranging from 2 to 5 seconds in duration but there were only 3 lean open loop events either 1 or 2 seconds in duration. A lean event at 730 seconds which occurred in the cold start and hot running tests was missing although the vehicle did operate very lean. There were two rich open loop events during the warm start test which did not occur in the other two tests. One of the additional rich open loop events was from the warm start test containing both rich open loop events which were only in one of the other two tests (at 1170 seconds during the cold start test and at 710 seconds during the hot running test). The other additional rich open loop event was from the rich open loop event at 1070 being split into two smaller peaks.

All of the rich open loop events for all three tests occurred when the load reached approximately 0.750. All of the lean open loop events occurred when the load was at approximately 0.1, and the vehicle was decelerating and occurred between 43 and 51 mph.

In the plots of the catalyst temperature and the exhaust gas temperature (pre-catalyst temperature), the increases and decreases in both temperatures with variations in load can be seen with the catalyst temperature changes lagging behind the changes in exhaust gas temperature. The hot running test was begun after allowing the vehicle to idle for one minute after the completion of the previous test before beginning the test. The acceleration test begins with a two minute idle, and Figure 3.3.4.5b shows the exhaust gas temperature coming to an equilibrium temperature of approximately 560°F. This relatively cool gas running over the catalyst cooled the catalyst from 925 to 750°F during the two minute idle. For the warm start test the vehicle was shut off after the previous test and allowed to rest for ten minutes before starting the test. During this ten minute rest, the catalyst did not cool as much as it did during the idle before the hot running test because it did not have the relatively cool exhaust gas removing heat from it; therefore it was hotter at the beginning of the warm start test than at the beginning of the hot running test.

As described earlier, the light off temperature of the catalyst is defined by Ford as the temperature at which the catalyst efficiency reaches 50% (Jesion, 1993). To determine the light off temperature of the catalyst in the test vehicle, the catalyst efficiencies for HC, CO and NO_x during the cold start phase of the UCLA acceleration cycle (Figure 3.3.4.4d) were compared to the emission rates (Figure 3.3.4.4c) and the catalyst temperature (Figure 3.3.4.4b). Although Ford suggests the light off temperature of the catalyst is approximately 800°F, during the test the light off temperature was estimated to be approximately 400°F. The same comparison could not be done for the hot start or warm start phases because the catalyst efficiency for these tests was greater than 50% at the beginning of the tests (Figures 3.3.4.5d and 3.3.4.6d).

The increased emissions of HC, CO and NO_x from the rich open loop events are apparent in Figures 3.3.4.4c, 3.3.4.5c and 3.3.4.6c. Because the emissions from these events did not only occur during the open loop operation but the tails of the emissions continued for several seconds after the events due to mixing lag in the exhaust pipe and the emissions sampling system, quantifying the emissions required integrating the emission rates from the start of open loop operation until the emission rates returned to baseline (stoichiometric emission rates). The integration of the emission rates was done by hand from the one second emission rate data. To determine the baseline emission rates of the three pollutants, the average emission rate including the rich open loop events was determined (0.0023 g s^{-1} for HC, 0.0927 g s^{-1} for CO and 0.0039 g s^{-1} for NO_x). All data greater than these average emission rates were removed and the averages were determined again (0.0014 g s^{-1} for HC, 0.0119 g s^{-1} for CO and 0.0016 g s^{-1} for NO_x). The emission rate from the beginning of open loop operation until the emission rates returned to these values was summed and then divided by the number of seconds of open loop operation in the event. Because this procedure produced a conservative (possibly too high) estimate of the baseline, the integrated emission rates during rich open loop operation should be conservative (lower than the possible maximum). The calculations for each of the rich open loop events are given in Appendices A.6.1, A.6.2 and A.6.3 for the cold start, hot running and warm start phases respectively, with a summary by speed given in Appendix A.6.4. No difference was found in the emission rates during rich open loop operation as a function of speed, although the range of speeds at which open loop operation occurred was narrow (37.4 to 58.9 mph).

The rich open loop emission rates determined by this procedure for each pollutant are shown in Table 3.3.4.1. with the average of the emission rates from the UCLA freeway and urban hot running tests given as the stoichiometric emission rates (there was one occurrence of rich open loop operation during the UCLA urban hot running test which was removed from the data set). The table shows the increase in emission rates during rich open loop operation were 96 times the stoichiometric rate for HC, 1735 times the stoichiometric rate for CO and 80 times the stoichiometric rate for NO_x and the average speed at which these events occurred during the pattern was 50.8 mph.

As mentioned earlier, Kelly and Groblicki (1992) conducted 10.6 hours (38,160 seconds) of driving a vehicle instrumented with emissions analyzers in Los Angeles. These researchers measured the emission rates of HC and CO during on-road rich open loop operation to be 0.024 and 4.0 g s^{-1} respectively compared to 0.00060 and 0.0016 g s^{-1} when running at stoichiometry (40 and 2500 times the stoichiometric rates during rich open loop operation). Unlike in the present study, they found no increase in NO_x emissions during rich open loop operation. Their measurements for emission rates of HC and CO during both rich open loop operation and running at stoichiometry are close to the values measured in this study on the dynamometer but the difference for NO_x emissions cannot be explained at this time.

3.4 Emissions Modeling

3.4.1 Model Validation

Emission rates for each of the 21 dynamometer driving tests were modeled by

Table 3.3.4.1 Rich open loop emission rates measured during driving of the UCLA Acceleration Driving Schedule on a dynamometer.

	HC $g\ s^{-1}$	CO $g\ s^{-1}$	NO_x $g\ s^{-1}$
Rich open loop	0.0376	3.167	0.1059
Stoichiometric	0.0004	0.0018	0.0013
Increase over stoichiometric	96	1735	80

both of the emissions models to compare the modeled emission rates to the measured emission rates. The modeled and measured emission rates for each of the tests by both models are given in Appendix A.7. The average difference between the modeled and the measured emission rates are given in Table 3.4.1.1. The data show the load-based model had a lower percent difference and a lower standard deviation than the acceleration-based model for all three pollutants. However, both models underestimated all three pollutants and were most accurate for NO_x followed by HC and then by CO.

Examination of the HC emission rates calculated by the two models for the individual phases of each test are compared in Figures 3.4.1.1 and 3.4.1.2. Both models over-estimated HC emissions for cold start, and then under-estimated HC emissions for the other two phases with the exception of the models over-estimating HC emissions for the hot running and warm start phases. Results are also shown for the adjusted length FTP (as described in Section 3.3.3) which decreased the difference for cold start for the FTP but increased the difference for warm start.

The emission rates of CO for both models are shown in Figures 3.4.1.3 and 3.4.1.4. For both models, CO emissions for the UCLA freeway pattern were under-estimated for all three phases, and CO emissions for the UCLA acceleration pattern were over-estimated. Emission rates for the HFET were also significantly under-estimated by both models.

The emission rates modeled for NO_x by both models are shown in Figures 3.4.1.5

Table 3.4.1.1 Comparison of percent differences between measured emissions for five driving patterns driven on a dynamometer and modeled emissions from two models.

Exhaust component	% Difference (SD) Load and Accel model	% Difference (SD) Speed and Accel model
Hydrocarbons (HC)	-28.1 (52.3)	-31.8 (64.6)
Carbon Monoxide (CO)	-55.4 (88.0)	-56.7 (96.4)
Oxides of Nitrogen (NO_x)	-8.2 (43.0)	-8.6 (52.6)

and 3.4.1.6. Similar to the results for CO, the models underestimated the emissions for the UCLA freeway pattern and over-estimated emissions for the UCLA acceleration pattern. The size of the bars show the load-based model to have a smaller variation than the acceleration based model.

The actual accuracy of the model in predicting on-road emission rates should be better for the load-based model than the acceleration-based model because the former is able to include emissions caused by high loads on grades. The acceleration-based model will not be able to differentiate between an acceleration of 3 mph s^{-1} from 20 mph uphill versus downhill. For the load-based model, the increased work on the engine will be included in the calculation of the load and therefore in the calculation of the emissions. Although there are problems with the accuracy of the present models for HC and CO, it is important to note the evaluation is based on limited emission measurements and limited emission bin size. With a larger emissions "inventory" and more powerful computers to allow for smaller bin size, the accuracy of the models should increase.

3.4.2 Predicted On-Road Emissions and Comparison to Certification Emissions Standards

The average modeled emissions rates for the on-road driving patterns in the

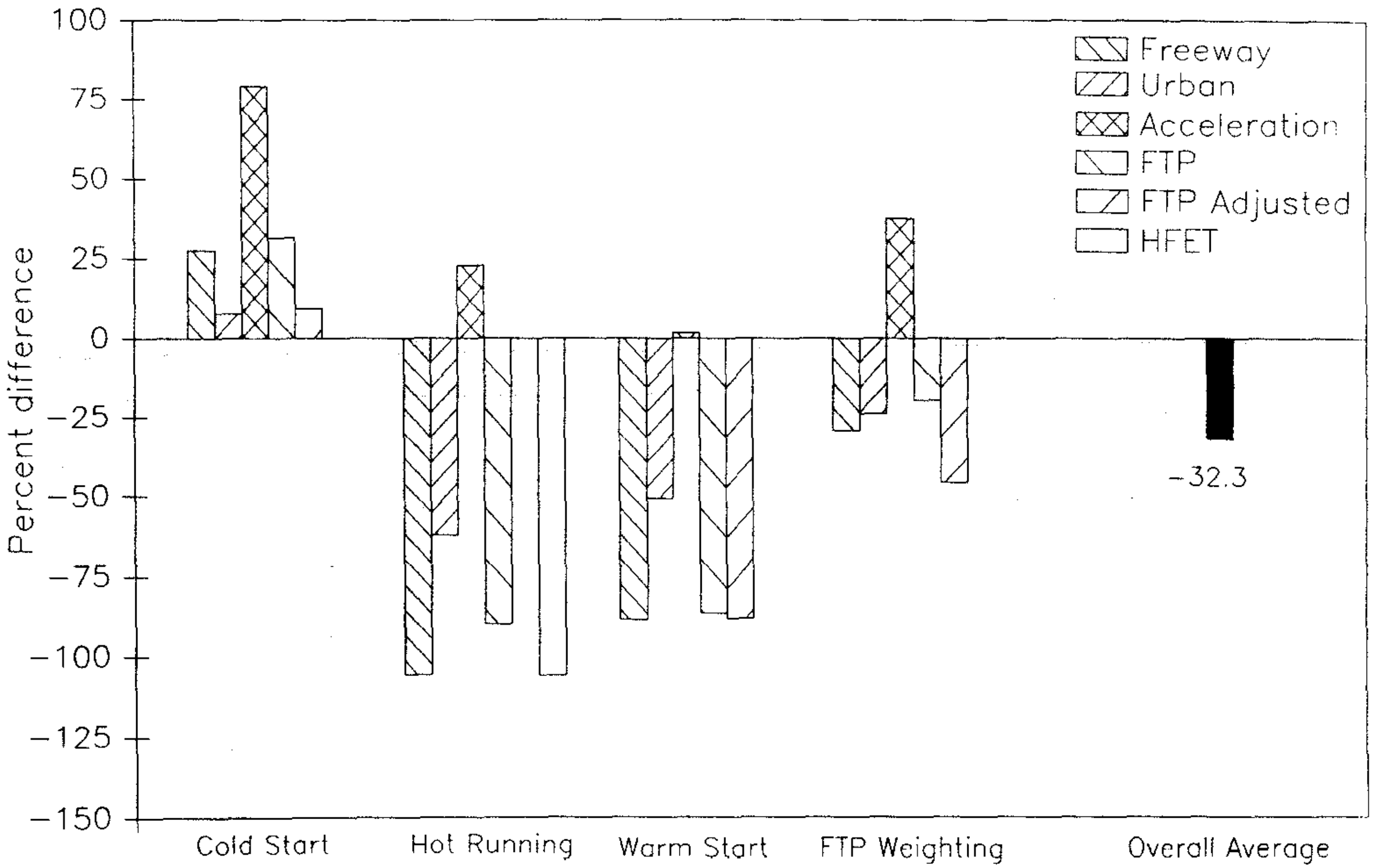

Figure 3.4.1.1 **Percent difference between dynamometer measured and load based modeled HC emissions for five driving patterns.**

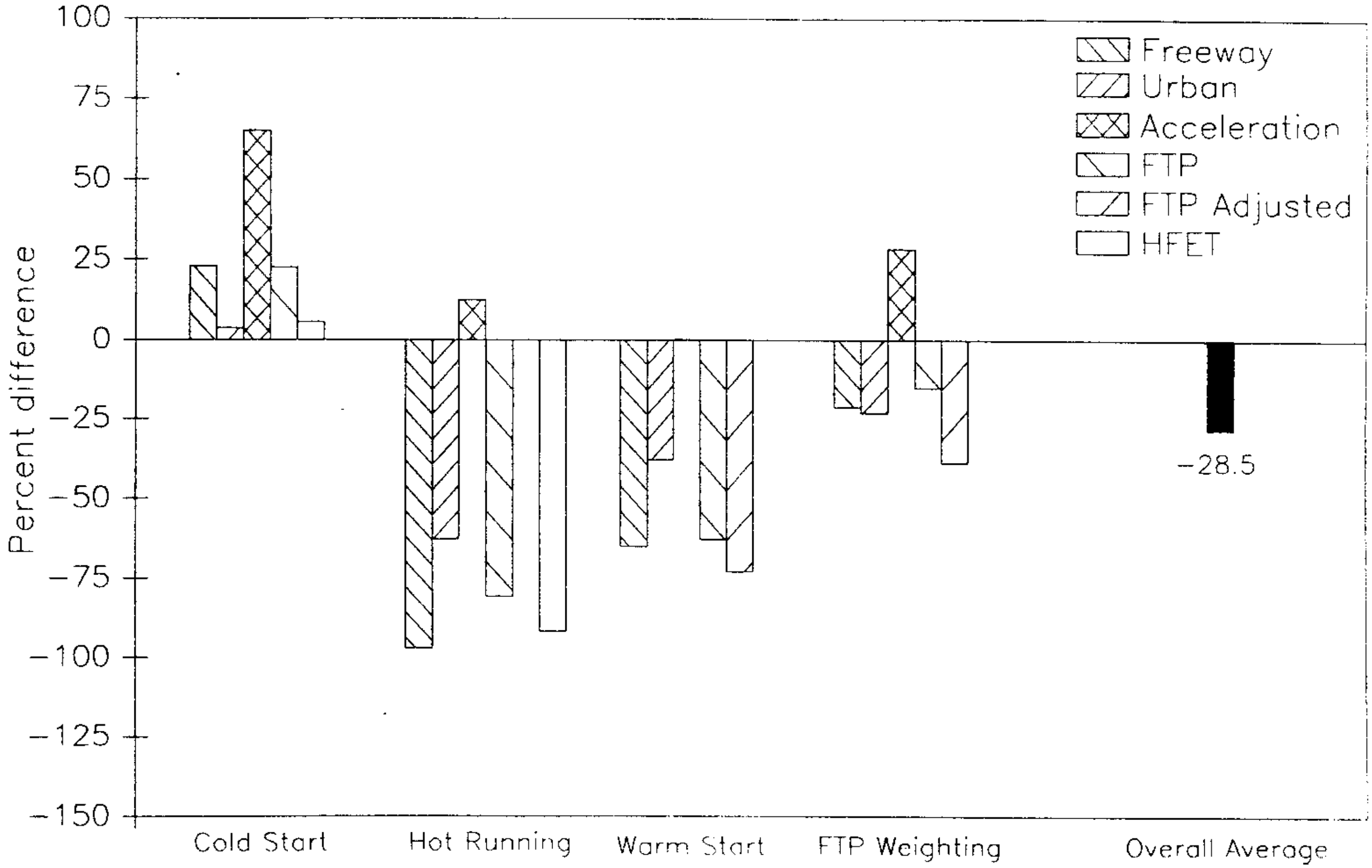

Figure 3.4.1.2 **Percent difference between dynamometer measured and acceleration based modeled HC emissions for five driving patterns.**

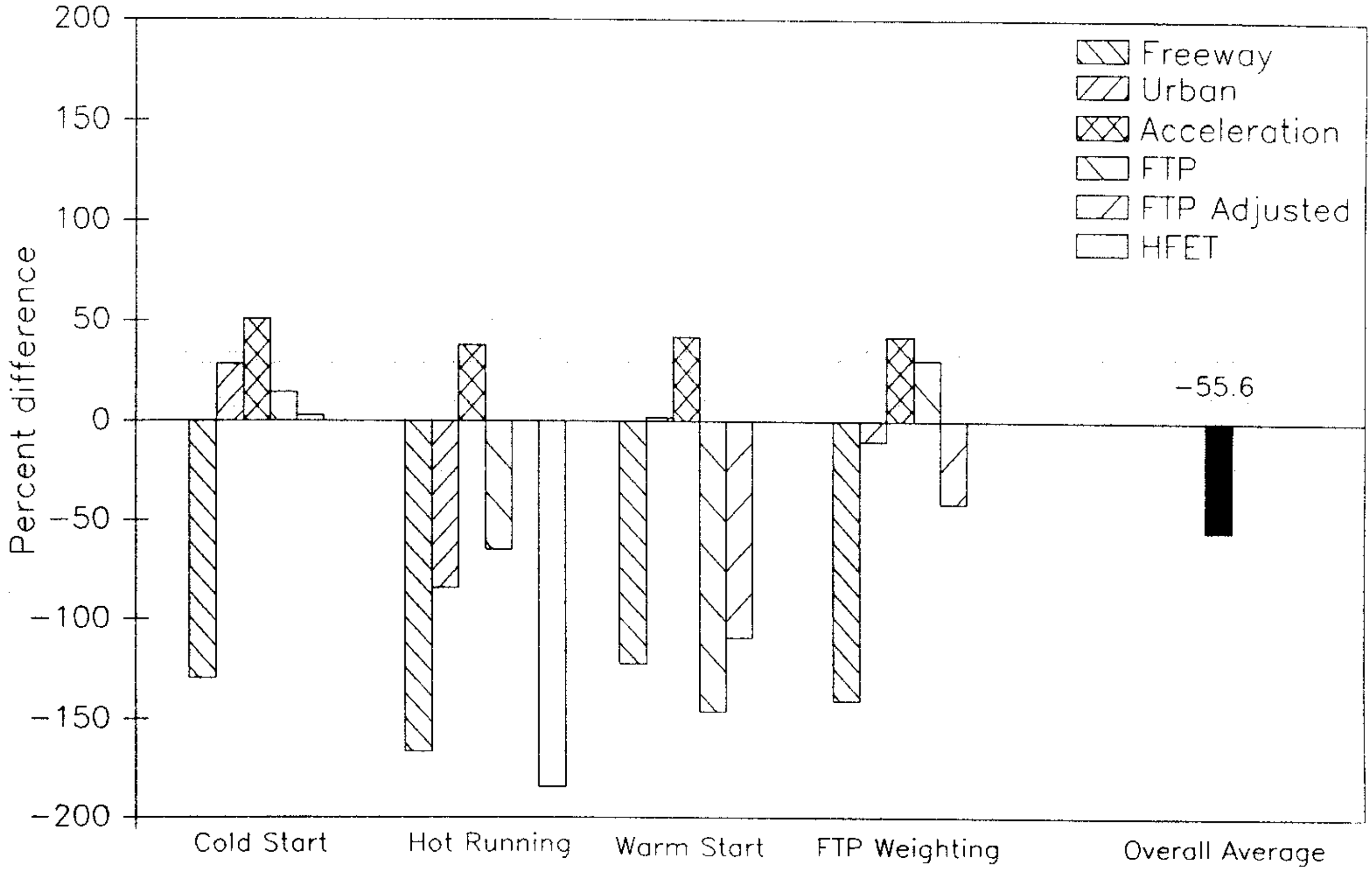

Figure 3.4.1.3 Percent difference between dynamometer measured and load based modeled CO emissions for five driving patterns.

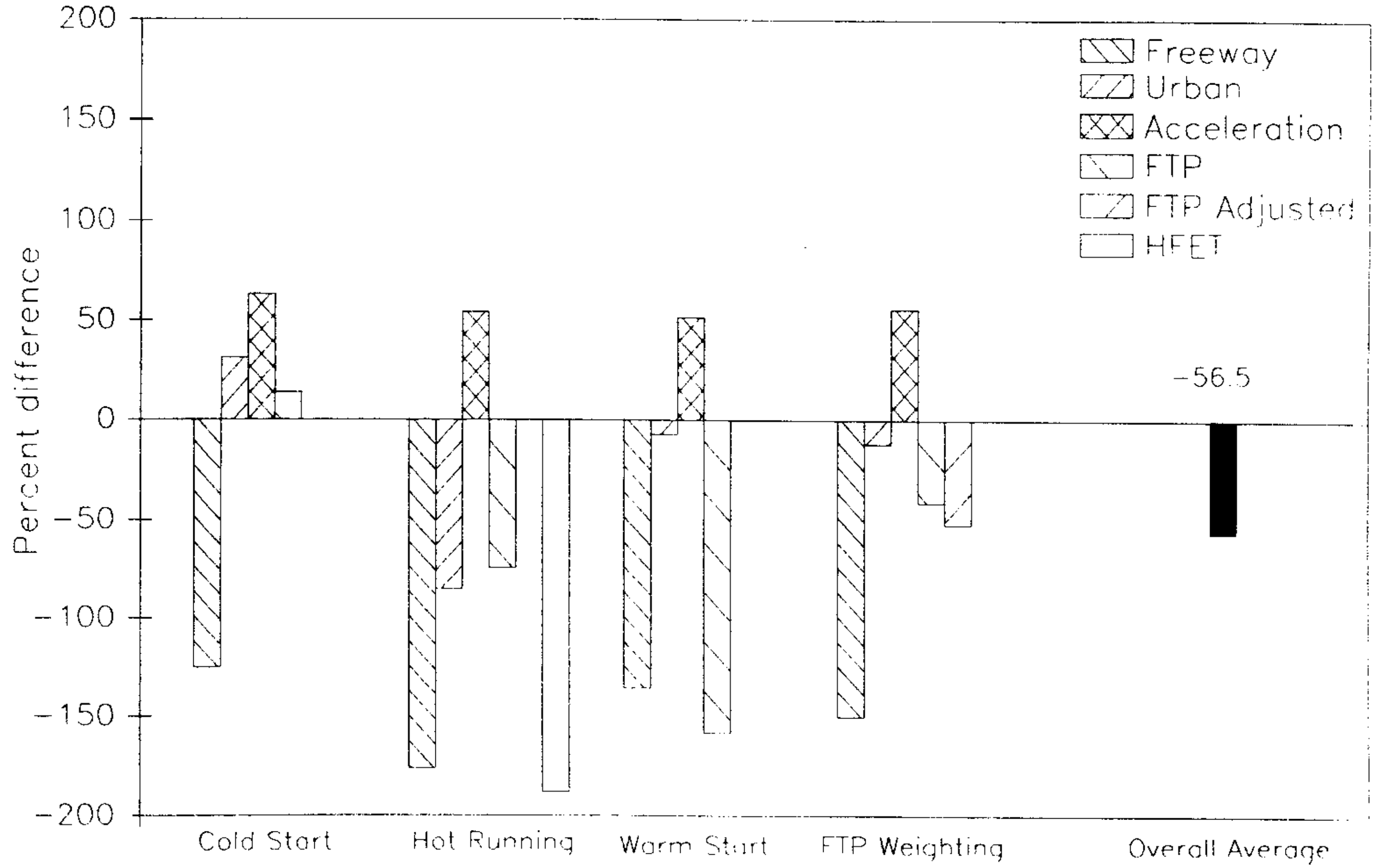

Figure 3.4.1.4 **Percent difference between dynamometer measured and acceleration based modeled CO emissions for five driving patterns.**

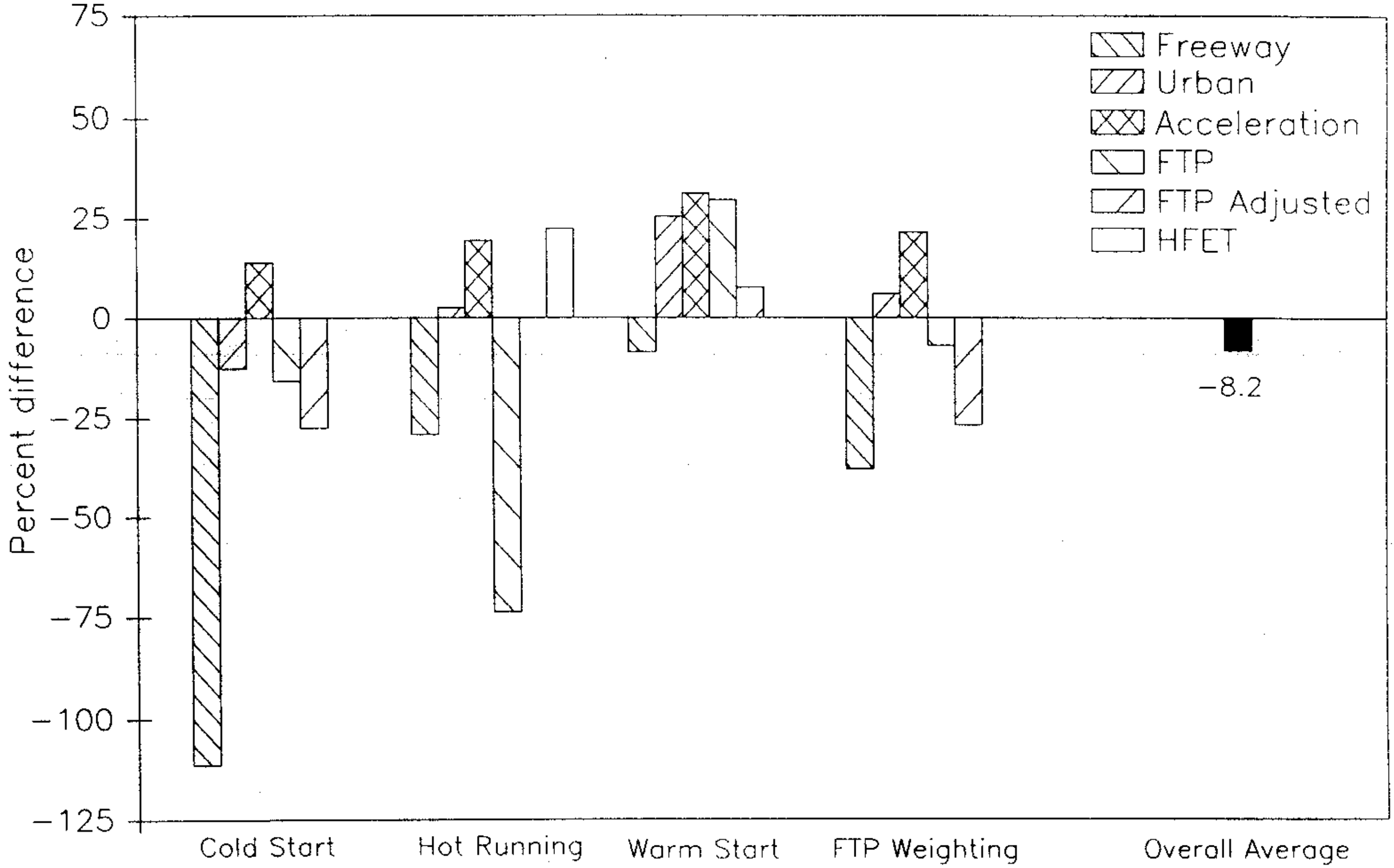

Figure 3.4.1.5 Percent difference between dynamometer measured and load based modeled NO_x emissions for five driving patterns.

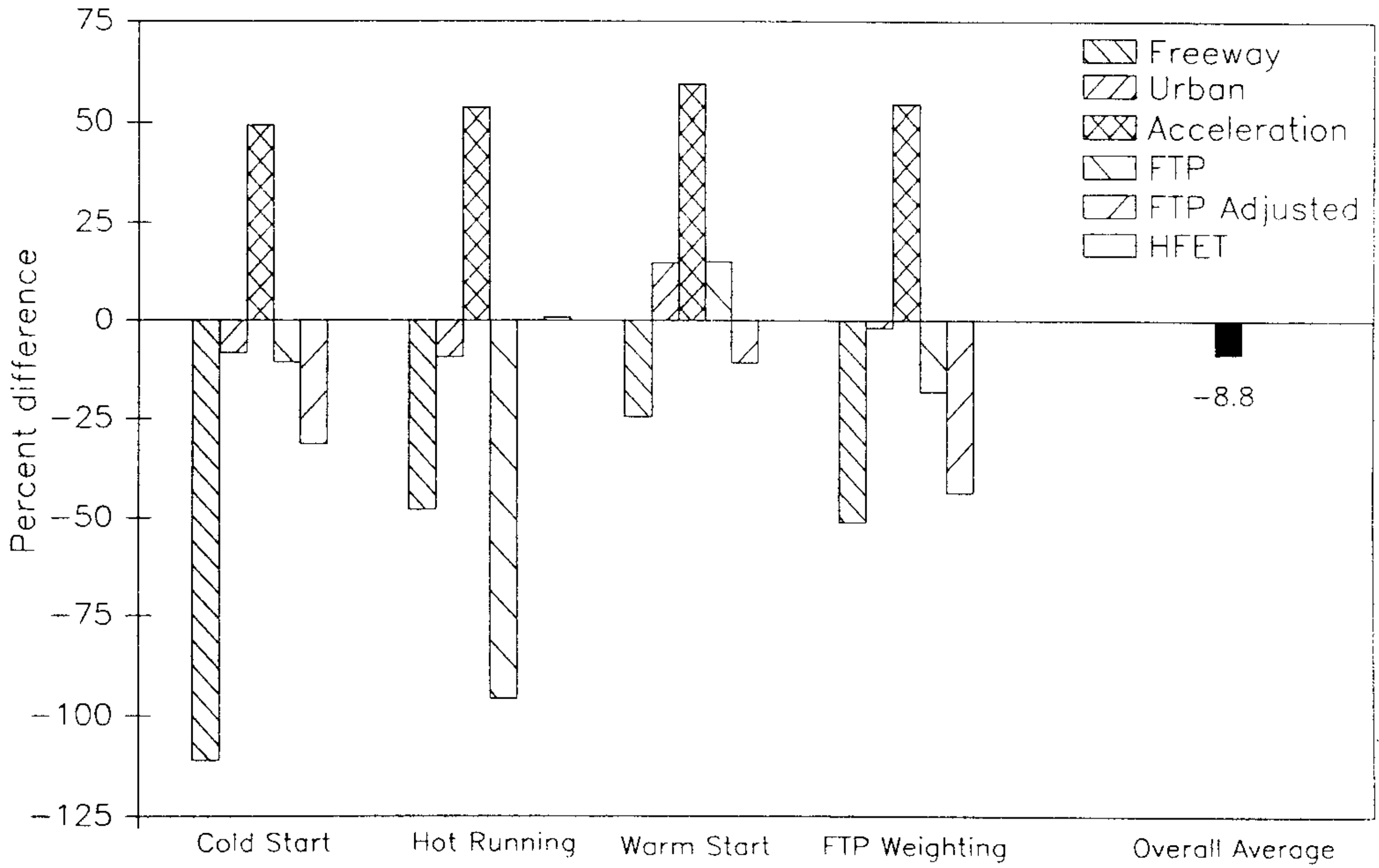

Figure 3.4.1.6 Percent difference between dynamometer measured and acceleration based modeled NO_x emissions for five driving patterns.

SoCAB for both models are given in Table 3.4.2.1. The emission rates are listed for each phase (cold start, hot running and warm start) with FTP weighting for each pattern type. The modeled emission rates for HC, CO and NO_x are also shown in Figures 3.4.2.1, 3.4.2.2 and 3.4.2.3 for both models with the California emission standards [30] for comparison. The modeled emission rates for the 32 individual conservative driving patterns and the 8 individual aggressive driving patterns are given in Appendices A.7.1 through A.7.6 by phase modeled.

Both models predict the same trends by driving pattern, however the load-based model had higher emission rates for aggressive driving pattern data than the acceleration-based model but lower emission rates for the conservative driving pattern data. Overall, the on-road average emission rates for all three components were slightly higher for the load-based model. Emission rates of CO and NO_x were higher for aggressive driving routes, however the HC emission rates were approximately equivalent. In all cases, the modeled on-road emission rates of CO, HC and NO_x were higher than the measured emissions for the FTP but were lower than the California emissions standards, with the exception of NO_x for the load-based model.

Modeled emissions from both models showed aggressive driving caused higher emission rates of CO and NO_x than conservative driving (6.8 versus 3.1 g mi^{-1} and 0.49 versus 0.26 g mi^{-1} respectively) but approximately no difference in the HC emission rate (0.29 versus 0.28 g mi^{-1}). Comparison of the results for freeway versus urban routes showed HC emission rates higher for urban routes (0.24 versus 0.33 g mi^{-1} respectively), CO slightly higher (5.2 versus 4.7 g mi^{-1} respectively) and no difference for NO_x (0.38 versus 0.37 g mi^{-1} respectively).

On-road in the SoCAB, the test vehicle operated rich open loop an average of 0.4 percent of the time. The percent time and the emission rates during rich open loop operation were applied to the average speed of the FTP, and the expected increases in emission rates for each of the three compounds due to rich open loop operation were calculated. These increased emission rates are compared in Table 3.4.2.2. The difference between the measured emission rate and the on-road average for CO was 3.2 g mi^{-1}

Table 3.4.2.1 Predicted emissions by acceleration- and load-based models for conservative and aggressive on-road driving patterns.

Bag &	HC, g/mi			CO, g/mi			NOx, g/mi		
Pattern	Accel	Load	% Difference	Accel	Load	% Difference	Accel	Load	% Difference
Cold Start:									
Conservative Freeway	0.547	0.583	-6.6	5.989	5.362	10.5	0.310	0.282	8.9
Aggressive Freeway	0.477	0.515	-8.0	6.598	6.986	-5.9	0.357	0.414	-16.0
Conservative Urban	0.790	0.845	-6.9	6.562	6.300	4.0	0.288	0.271	5.8
Aggressive Urban	0.591	0.665	-12.5	7.059	7.581	-7.4	0.362	0.496	-36.9
Hot Running:									
Conservative Freeway	0.134	0.127	5.4	4.270	3.577	16.2	0.342	0.331	3.0
Aggressive Freeway	0.175	0.176	-1.1	6.282	7.501	-19.4	0.408	0.506	-23.9
Conservative Urban	0.141	0.148	-4.8	1.180	1.221	-3.4	0.208	0.207	0.6
Aggressive Urban	0.194	0.241	-24.3	7.104	7.968	-12.2	0.450	0.575	-27.7
Warm Start:									
Conservative Freeway	0.184	0.141	23.3	3.480	2.595	25.4	0.286	0.253	11.3
Aggressive Freeway	0.181	0.158	12.6	4.629	5.030	-8.6	0.349	0.406	-16.4
Conservative Urban	0.331	0.251	24.2	2.112	1.693	19.9	0.325	0.206	36.6
Aggressive Urban	0.237	0.246	-3.6	4.172	4.479	-7.3	0.337	0.457	-35.6
Weighted Averages:									
Conservative Freeway	0.237	0.229	3.4	4.415	3.681	16.6	0.319	0.298	6.4
Aggressive Freeway	0.241	0.244	-1.1	5.879	6.686	-13.7	0.380	0.458	-20.3
Conservative Urban	0.335	0.327	2.3	2.603	2.447	6.0	0.259	0.220	14.7
Aggressive Urban	0.292	0.334	-14.4	6.259	6.890	-10.1	0.399	0.525	-31.4
Freeway Average	0.239	0.236	1.1	5.147	5.183	1.4	0.350	0.378	-7.0
Urban Average	0.313	0.330	-6.0	4.431	4.669	-2.0	0.329	0.372	-8.3
Conservative	0.286	0.278	2.8	3.509	3.064	11.3	0.289	0.259	10.6
Aggressive	0.267	0.289	-7.7	6.069	6.788	-11.9	0.390	0.491	-25.9
All	0.276	0.283	-2.4	4.789	4.926	-0.3	0.339	0.375	-7.7

compared to the calculated increase due to rich open loop operation of 2.3 g mi^{-1}. The remainder of the increase over the FTP (0.9 g mi^{-1}) is attributed to differences between the on-road patterns and the pattern used in the FTP (the UDDS). The on-road patterns also include changes in load such as grades which are not included in the FTP driven on a dynamometer. Similar results are shown in the table for HC (0.07 g mi^{-1} difference versus 0.03 g mi^{-1} calculated) and for NO_x (0.20 g mi^{-1} difference versus 0.08 g mi^{-1} calculated), both with approximately half of the emissions coming from rich open loop operation.

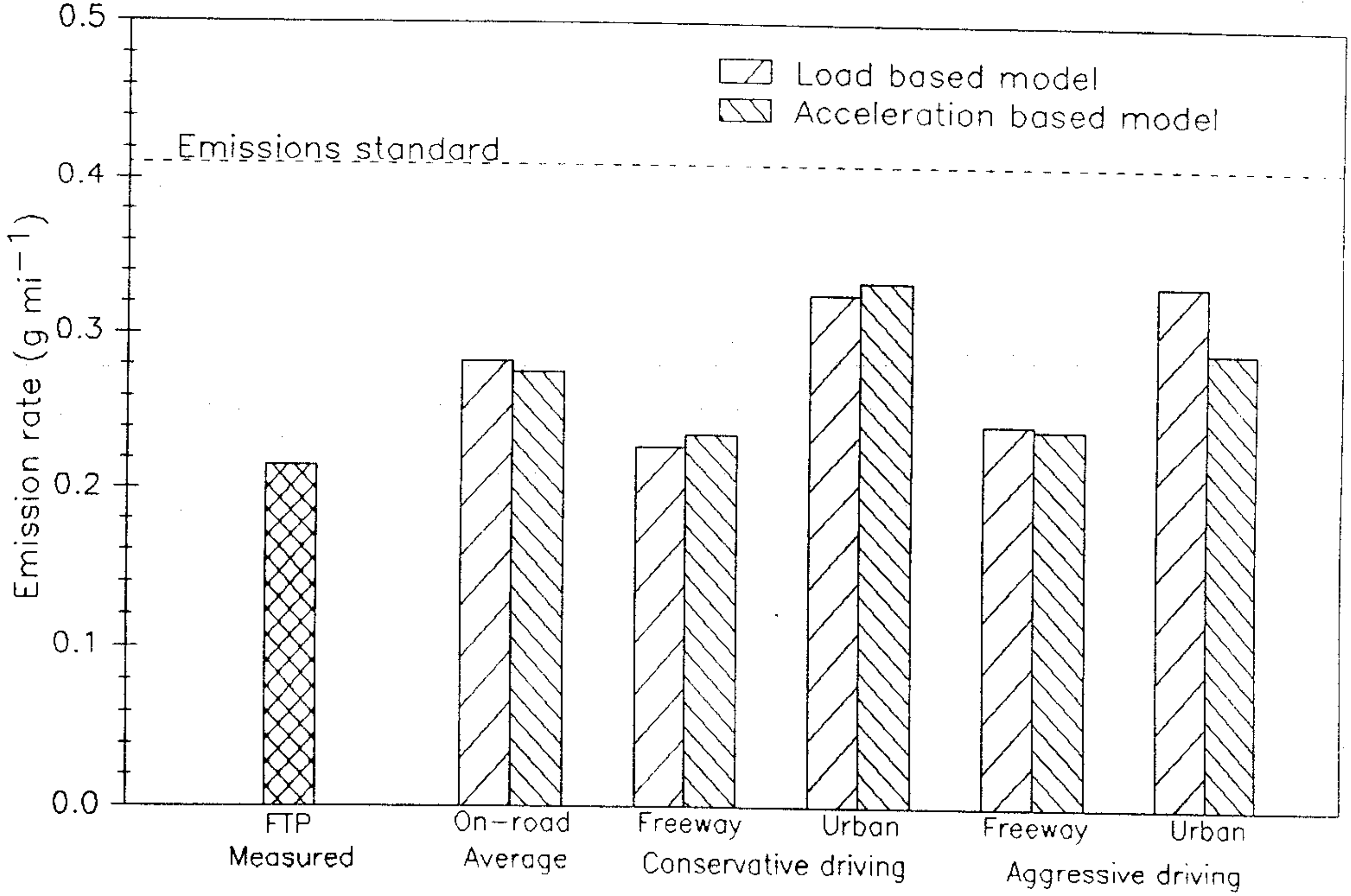

Figure 3.4.2.1 FTP measured and modeled on-road HC emission rates by model.

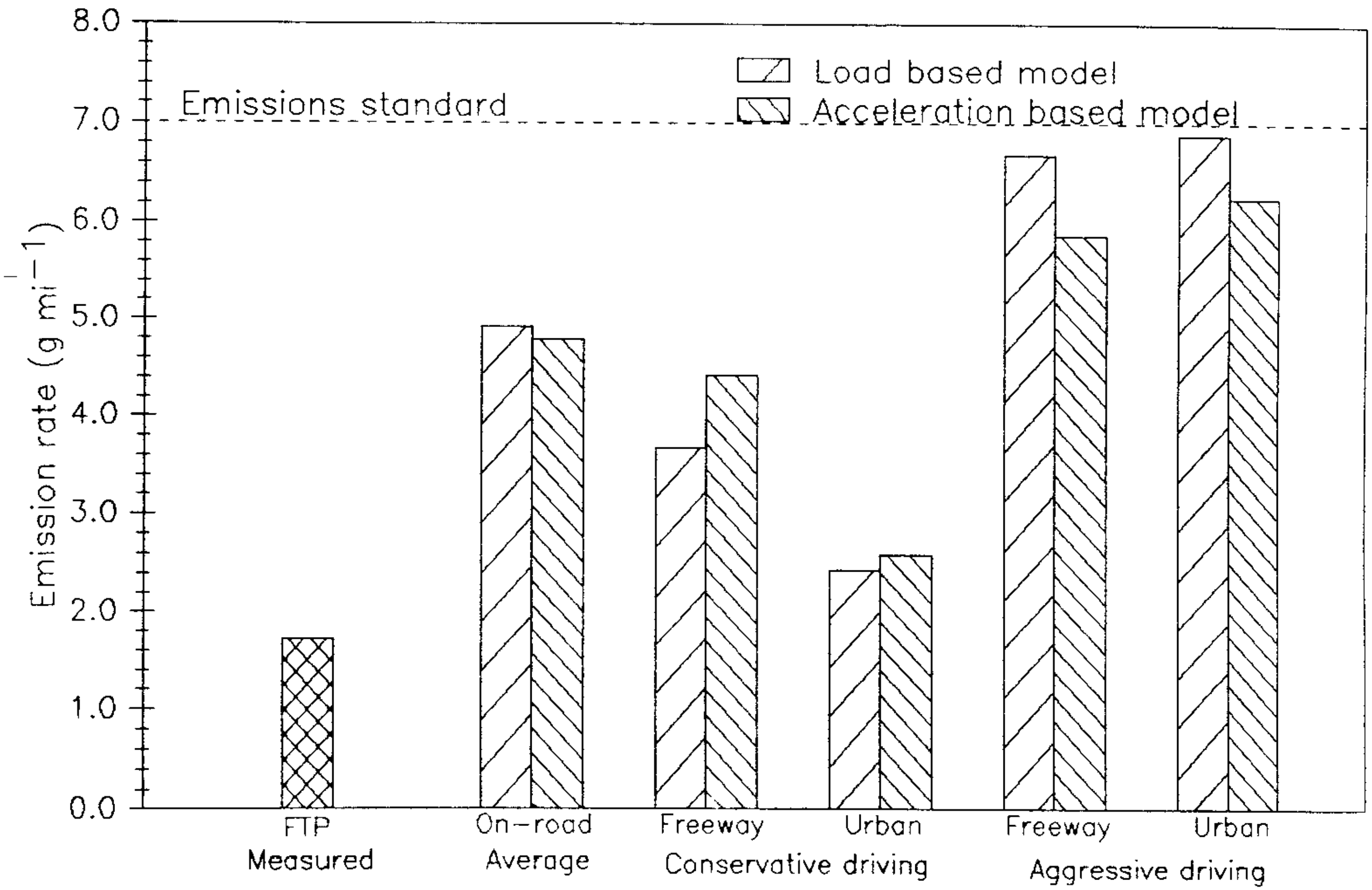

Figure 3.4.2.2 **FTP measured and modeled on-road CO emission rates by model.**

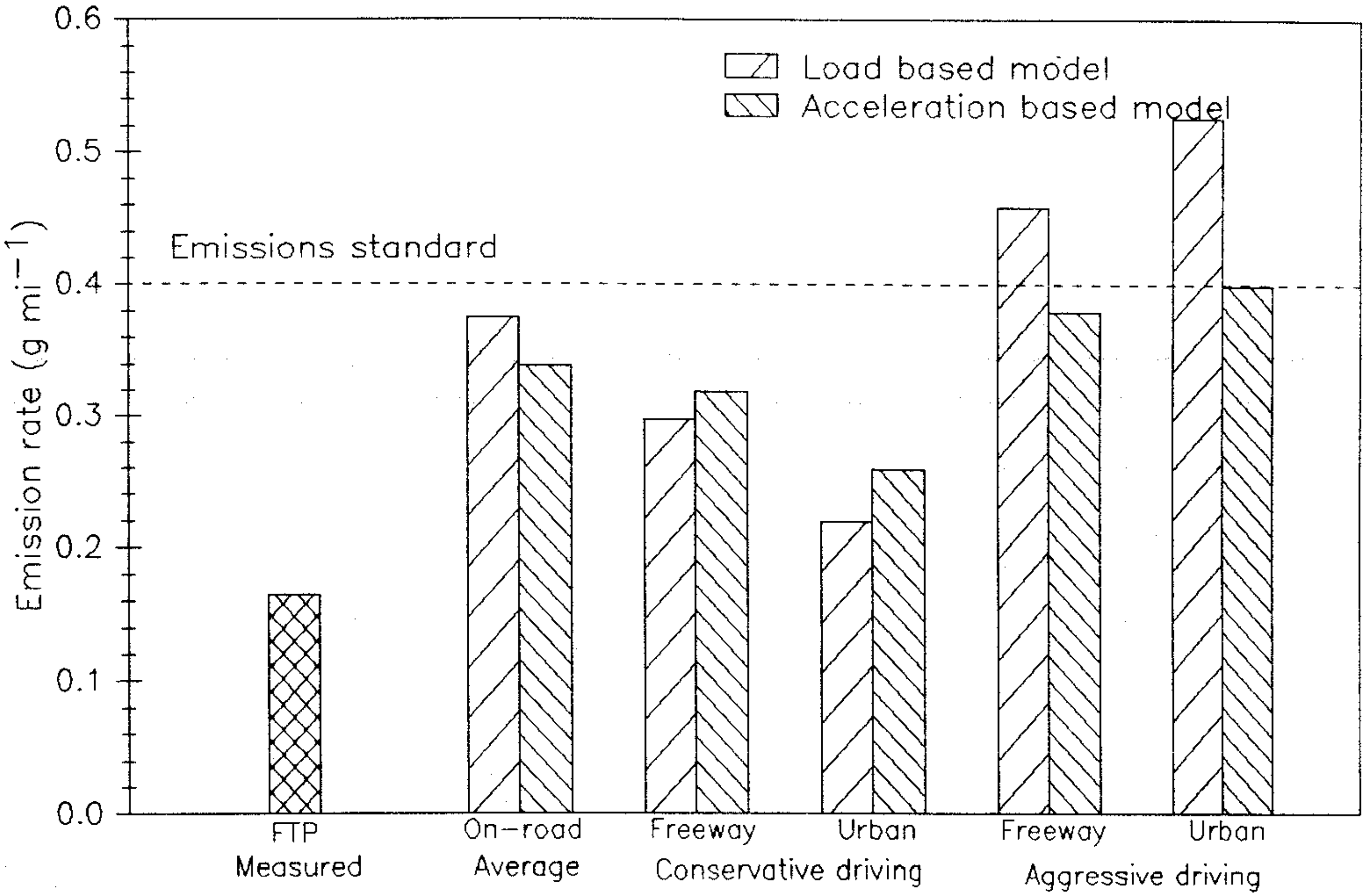

Figure 3.4.2.3 FTP measured and modeled on-road NO_x emission rates by model.

Table 3.4.2.2. Difference between measured and modeled on-road emission rates compared to the calculated increase due to rich open loop operation.

Pollutant	FTP measured ($g\ mi^{-1}$)	On-road average ($g\ mi^{-1}$)	Difference ($g\ mi^{-1}$)	Increase due to rich open loop ($g\ mi^{-1}$)
HC	0.21	0.28	+ 0.07 (33%)	0.03 (40%)
CO	1.7	4.9	+ 3.2 (190%)	2.3 (70%)
NO_x	0.17	0.37	+ 0.20 (120%)	0.08 (40%)

4.0 - CONCLUSIONS AND RECOMMENDATIONS

In summary, we have found differences between the Urban Dynamometer Driving Pattern used in the Federal Test Procedure and on-road driving conditions in the SoCAB which are important contributors to vehicle emissions. The most important differences were higher speeds and higher acceleration rates on-road than in the FTP and differences in open loop operation.

The average on-road speeds were 29.3 mph for conservative driving and 33.1 mph for aggressive driving compared to 20.7 mph for the FTP and the maximum acceleration rates on-road were 8.0 mph s^{-1} for conservative driving and 10.0 mph s^{-1} for aggressive driving compared to 3.3 mph s^{-1} for the FTP. The fuel economy measured on-road was higher than during the FTP (23.1 mpg) for both conservative and aggressive driving (28.6 and 24.7 mpg). The average distance per stop was greater on-road for both conservative and aggressive driving (2.8 and 3.7 miles per stop) compared to the FTP (0.46 miles per stop).

For the 1991 Flexible Fuel Ford Taurus test vehicle, rich open loop operation was not observed during the FTP or HFET. However, it was observed while driving on-road in a conservative manner in congested traffic conditions on freeway and urban routes in the SoCAB (0.003 and 0.007% of the time respectively). On-road aggressive driving experiments also conducted in congested traffic conditions, found aggressive driving to greatly increase the frequency of rich open loop operation over conservative driving (0.44% of the time for freeway routes and 1.1% of the time for urban routes). Up-hill grades and merging were also found to raise the frequency of rich open loop operation due to the increased load on grades (including up-hill on ramps) and due to the high rates of acceleration necessary while merging. Rich open loop operation was also found to occur more frequently in free flowing traffic than in congested or grid-locked traffic, possibly due to the low velocities and close proximity of the vehicles in grid-lock.

Emissions tests were conducted with the Taurus vehicle using the FTP and two new UCLA dynamometer driving schedules which were developed to be representative of the current on-road freeway and urban routes in the SoCAB. The average of the emission rates of HC, CO and NO_x for the UCLA driving schedules (freeway and urban) were all higher compared than the FTP. The average emission rates during for the UCLA driving schedules compared to the FTP were 0.167 versus 0.147 g mi^{-1} for HC, 2.729 versus 1.715 g mi^{-1} for CO and 0.221 versus 0.118 g mi^{-1} for NO_x. In addition to the freeway and urban driving schedules, emissions tests were conducted using a special high acceleration rate driving schedule which was developed to cause open loop operation to occur. Emission rates during rich open loop operation were measured to be 96 times higher than the stoichiometric rate for HC (0.0376 g mi^{-1} during open loop operation), 1735 times the stoichiometric rate for CO (3.167 g mi^{-1}) and 80 times the stoichiometric rate for NO_x (0.1059 g mi^{-1}).

The emission rates data recorded during the dynamometer tests were used in two new UCLA vehicle emissions models to predict on-road emission rates. Of the two models, the model based on using the load and speed of vehicle was found to be the most accurate of the two models. The model under predicted the actual emission rates of all three pollutants with a difference between dynamometer measured and predicted emission rates of -28.1% for HC, -55.4% for CO and -8.2% for NO_x. The under-prediction of the model was possibly due to the limited resolution in the model which was necessary because of limited emission rate data used as a model input.

The modeled on-road emission rates for the driving pattern data recorded on-road with the Taurus in the SoCAB, showed aggressive driving caused higher emission rates of CO and NO_x than conservative driving (6.8 versus 3.1 g mi^{-1} and 0.49 versus 0.26 g mi^{-1} respectively) but approximately no difference in the HC emission rate (0.29 versus 0.28 g mi^{-1}). Comparison of the results for freeway versus urban routes found the HC emission rate was higher for urban routes (0.24 versus 0.33 g mi^{-1} respectively), the CO emission rate was higher for freeway routes (5.2 versus 4.7 g mi^{-1} respectively), and there was no difference the emission rate of NO_x between freeway and urban routes (0.38 versus 0.37 g mi^{-1} respectively). With the exception of the NO_x emission rate during aggressive driving, all of the modeled on-road emission rates were lower than the current certification emissions standards, but they were also all greater then the emission rates measured for the FTP (33% for HC, 190% for CO and 120% for NO_x).

The cause of the higher emission rates on-road than for the FTP was attributed to the occurrence open loop operation on-road but not during the FTP and differences in the driving patterns on-road compared to the Urban Dynamometer Driving Schedule used in the FTP. For CO, 70% of the increase in the emission rate was determined to have come from open loop operation, with the remainder due to differences in the driving patterns. For both HC and NO_x, 40% of the increase was attributed to open loop operation with the remaining 60% attributed to differences between the FTP and on-road driving patterns.

The modeling data suggest emissions from rich open loop operation, because they are not included in the FTP, may account for a portion of the under-estimation in the mobile source emissions inventory. However, because the emissions modeling was only conducted for a single vehicle, it is difficult to draw conclusions about the entire in-use fleet. Comparison of the present results to the only other rich open loop operation data available suggests there can be large variances in the frequency of open loop operation between manufacturers. In general, much more needs to be known about the frequency of rich open loop operation on-road and the emission rates during this operation from a variety of vehicles.

If rich open loop operation is not included in the emissions measurements which are used as inputs to emissions models, and if the emissions from these events account for a significant proportion of the total vehicle emissions, there will continue to be discrepancies between the emissions predicted by emissions models and real on-road emissions.

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APPENDICES

A.1 Data Analysis Programs

The source codes for the VDAS data analysis programs are listed in the following sections.

A.1.1 VDAS Data Analysis Program ANLYS50C.FOR

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C        PROGRAM ANLYS (DATA ANALYSIS PROGRAM FOR VDAS DATA)
C        SEPTEMBER 8, 1991    VER. 1.0
C        JANUARY 27, 1992     VER. 1.1
C        FEBRUARY 5, 1992     VER. 1.2
C        MARCH 3, 1992        VER. 1.3
C        MAY 9, 1992          VER. 2.0  ADD MODAL ANALYSIS
C        JUNE 22, 1992        VER. 3.0  ADD MODAL ANALYSIS BY SPEED
C        JULY 1, 1992         VER. 3.1  %OL BY LEAN/RICH
C        JULY 9, 1992         VER. 3.2  DETERMINE MAX ACCEL, DECL AND VEL
C        AUGUST 31, 1992      VER. 3.3  SETUP FOR INPUT THROUGH CONTROL
C        FILES
C        SEPTEMBER 1, 1992    VER. 3.4A CALCULATE MORE STATS
C        SEPTEMBER 9, 1992    VER. 3.4Z RUN THROUGH CONTROL FILES
C        SEPTEMBER 23, 1992   VER. 4.0A ADD CALCULATION OF PARAM STATS
C        SEPTEMBER 30, 1992   VER. 5.0A ADD MODAL ANALYSIS BY LOAD
C        FEBRUARY 9, 1993     VER. 5.0B ADD GM ENRICHMENT ANLYSIS
C        JUNE 17, 1993        VER. 5.0C FIX % IN LOAD MODES (OPEN LOOP)
C
C        *******************************************************
C
C        THIS PROGRAM WRITTEN BY:
C            MICHAEL J. ST. DENIS
C            ATMOSPHERIC INNOVATIVE RESEARCH
C            5025 DENNY AVENUE, #6
C            NORTH HOLLYWOOD, CA 91601
C            (818) 761-6048
C
C        WRITTEN FOR AND PROPERTY OF:
C            THE SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
C            21865 EAST COPELY DRIVE
C            DIAMOND BAR, CA 91765
C
C        *******************************************************
C
C        THIS PROGRAM READS IN A .DRW DATA FILE WHICH HAS BEEN
C        CONVERTED TO AN .AEU DATA FILE (ASCII) BY THE PROGRAM
C        V5CVT.EXE, AND FROM THE VELOCITY AND FUEL INJECTOR PULSE
C        WIDTH, CALCULATES THE DISTANCE TRAVELED, MPH AND MPG. THE
C        PROGRAM ALSO RECORDS OPEN LOOP OPERATION (NUMBER, FREQ
C        AND DURATION) AS WELL A STOPS (NUMBER, FREQ AND DURATION)
C
C        *******************************************************
C
C        VARIABLE DECLARATION SECTION
C
C        a(???) - ARRAY OF VARIABLE ???
C        ACAVG  - AVERAGE AIR CHARGE TEMPERATURE
C        ACLAVG - AVERAGE ACCELERATION MEASURED BY ACCELEROMETER
C        ACLMAX - MAXIMUM ACCELERATION
C        ACLMIN - MINIMUM ACCELERATION
C        ACLSM  - SUM OF ACCELEROMETER MEASUREMENTS
C        ACRU   - AVERAGE TIME IN MODE "CRUISE"
C        ACST   - AVERAGE TIME IN MODE "COAST"
C        ACTAVG - AVERAGE TIME WITH AIR CONDITIONING ON
C        ACTSM  - SUM OF TIME WITH AIR CONDITIONING ON
C        ACSM   - SUM OF AIR CHARGE TEMPERATURE MEASUREMENTS
C        ACTMAX - MAXIMUM AIR CHARGE TEMPERATURE
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C         ACTMIN - MINIMUM AIR CHARGE TEMPERATURE
C         AHACL  - AVERAGE TIME IN MODE "HARD ACCEL"
C         AHDCL  - AVERAGE TIME IN MODE "HARD DECEL"
C         ALACL  - AVERAGE TIME IN MODE "LIGHT ACCEL"
C         ALDCL  - AVERAGE TIME IN MODE "LIGHT DECEL"
C         AMACL  - AVERAGE TIME IN MODE "MEDIUM ACCEL"
C         AMDCL  - AVERAGE TIME IN MODE "MEDIUM DECEL"
C         AMTAVG - AVERAGE AMBIENT TEMPERATURE
C         AMTMAX - MAXIMUM AMBIENT TEMPERATURE
C         AMTMIN - MINIMUM AMBIENT TEMPERATURE
C         AMTSM  - SUM OF AMBIENT TEMPERATURE MEASUREMENTS
C         ANOSPD - AVERAGE TIME IN MODE "STOPPED"
C         AOLDUR - AVERAGE TIME OPEN LOOP
C         AORD   - ARRAY, ACCEL OR DECEL FOR OPEN LOOP OCCURRENCES
C         AVGVEL - CALCULATED AVERAGE VELICITY
C         B      - NUMBER OF OPEN LOOP OCCURRENCES
C         BKAVG  - PERCENT TIME BRAKING
C         BKSM   - SUMMATION OF TIME BRAKING (SEC)
C         C      - NUMBER OF LIGHT DECEL OCCURRENCES
C         CATAVG - AVERAGE CATALYST TEMPERATURE
C         CATMAX - MAXIMUM CATALYST TEMPERATURE
C         CATMIN - MINIMUM CATALYST TEMPERATURE
C         CATSM  - SUM OF CATALYST TEMPERATURE MEASUREMENTS
C         CLDSTR - FLAG IF START OCCURRED
C         COAST  - NUMBER OF CONTINOUS SECONDS IN COAST OCCURRENCE
C         CRUDR  - ARRAY, OCCURRENCES OF CRUISE BY DURATION
C         CSTDR  - ARRAY, OCCURRENCES OF COASTING BY DURATION
C         CSTRT  - LOAD MODE, WAS COLD START PRESENT (ECT <= 160 F)
C         DIST   - CALCULATED DISTANCE TRAVELED
C         DTFLNM - OUTPUT FILE FOR MODAL DATA SAVE FOR ANALYSIS
C         D      - NUMBER OF MEDIUM DECEL OCCURRENCES
C         ECTAVG - AVERAGE ENGINE COOLANT TEMPERATURE
C         ECTSM  - SUM OF ENGINE COOLANT TEMPERATURE MEASUREMENTS
C         EXGAVG - AVERAGE EXHAUST GAS TEMPERATURE
C         EXGSM  - SUM OF EXHAUST GAS TEMPERATURE MEASUREMENTS
C         ECTMAX - MAXIMUM ENGINE COOLANT TEMPERATURE
C         ECTMIN - MINIMUM ENGINE COOLANT TEMPERATURE
C         EXGMAX - MAXIMUM EXHAUST GAS TEMPERATURE
C         EXGMIN - MINIMUM EXHAUST GAS TEMPERATURE
C         F      - NUMBER OF STOP OCCURRENCES
C         FUEL   - TOTAL FUEL INJECTED INTO ENGINE DURING EXPERIMENT,
C                  GALLONS
C         getnum - FUNCTION, NUMBER OF CHANNELS IN DATA FILE
C         getlab - FUNCTION, INDICIES OF VARIABLES IN DATA FILE
C         GRAVG  - AVERAGE GEAR
C         GRMAX  - MAXIMUM GEAR
C         GRMIN  - MINIMUM GEAR
C         GRSM   - SUM OF GEAR MEASUREMENTS
C         H      - NUMBER OF HARD ACCEL OCCURRENCES
C         HACL   - NUMBER OF CONTINOUS SECONDS IN HARD ACCEL OCCURRENCE
C         HACLDR - ARRAY, OCCURRENCES OF HARD ACCELS BY DURATION
C         HDCL   - NUMBER OF CONTINOUS SECONDS IN HARD DECEL OCCURRENCE
C         HDCLDR - ARRAY, OCCURRENCES OF HARD DECLS BY DURATION
C         header - ARRAY, CONTAINS HEADER INFO FROM INPUT FILE
C         HLD    - LOAD MODE, HIGH LOAD
C         HORAVG - AVERAGE HORIBA AIR FUEL SENSOR AFR
C         HORMAX - MAXIMUM HORIBA AIR FUEL SENSOR AFR
C         HORMIN - MINIMUM HORIBA AIR FUEL SENSOR AFR
C         HORSM  - SUM OF HORIBA AIR FUEL SENSOR AFR MEASUREMENTS
C         HSTRT  - LOAD MODE, WAS A HOT START PRESENT (ECT > 160 F)
C         I      - LOOP COUNTER
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C        iaf    - INDICIE OF LAMBDA VARIABLE IN INPUT FILE
C        ibrake - INDICIE OF BRAKE VARIABLE IN INPUT FILE
C        ifpw   - INDICIE OF FUEL PULSE WIDTH VARIABLE IN INPUT FILE
C        ilen   - STRING OF HEADER
C        INFLNM - INPUT FILE WITH .AEU VDAS DATA
C        INSTSP - DISTANCE TRAVELED AT GIVEN SPEED IN ONE SECOND
C        iolf   - INDICIE OF OPEN LOOP FLAG VARIABLE IN INPUT FILE
C        irpm   - INDICIE OF RPM VARIABLE IN INPUT FILE
C        ispeed - INDICIE OF VELOCITY VARIABLE IN INPUT FILE
C        itime  - INDICIE OF TIME VARIABLE IN INPUT FILE
C        itp    - INDICIE OF REL THROTTLE POSITION VARIABLE IN INPUT FILE
C        L      - NUMBER OF LIGHT ACCEL OCCURRENCES
C        LACL   - NUMBER OF CONTINOUS SECONDS IN LIGHT ACCEL OCCURRENCE
C        LACLDR - ARRAY, OCCURRENCES OF LIGHT ACCLS BY DURATION
C        LDCL   - NUMBER OF CONTINOUS SECONDS IN LIGHT DECEL OCCURRENCE
C        LDCLDR - ARRAY, OCCURRENCES OF LIGHT DECLS BY DURATION
C        LLD    - LOAD MODE, LOW LOAD
C        LODAVG - AVERAGE ENGINE LOAD
C        LODMAX - MAXIMUM ENGINE LOAD
C        LODMIN - MINIMUM ENGINE LOAD
C        LODSM  - SUM OF ENGINE LOAD MEASUREMENTS
C        LOL    - NUMBER OF SECONDS IN LEAN OPEN LOOP OPERATION
C        M      - NUMBER OF MEDIUM ACCEL OCCURRENCES
C        MACL   - NUMBER OF CONTINOUS SECONDS IN MEDIUM ACCEL OCCURRENCE
C        MACLDR - ARRAY, OCCURRENCES OF MEDIUM ACCELS BY DURATION
C        MAXACL - MAXIMUM ACCELERATION
C        MAXVS  - MAXIMUM ACCELERATION
C        MAXDCL - MAXIMUM DECELERATION
C        MDCL   - NUMBER OF CONTINOUS SECONDS IN MEDIUM DECEL OCCURRENCE
C        MDCLDR - ARRAY, OCCURRENCES OF MEDIUM DECLS BY DURATION
C        MHLD   - LOAD MODE, MEDIUM HIGH LOAD
C        MIN    - TIME OF TRAVEL IN MINUTES
C        MLLD   - LOAD MODE, MEDIUM LOW LOAD
C        MPG    - FUEL ECONOMY IN MILES PER GALLON
C        NOSPD  - NUMBER OF CONTINOUS SECONDS IN STOP OCCURRENCE
C        OCRU   - PERCENT OF CRUISE OCCURRENCES
C        OCST   - PERCENT OF COAST OCCURRENCES
C        OHACL  - PERCENT OF HARD ACCEL OCCURRENCES
C        OHDCL  - PERCENT OF HARD DECEL OCCURRENCES
C        OLACL  - PERCENT OF LIGHT ACCEL OCCURRENCES
C        OLDCL  - PERCENT OF LIGHT DECEL OCCURRENCES
C        OLLD   - LOAD MODE, TIME OPEN LOOP, LEAN AND RICH COMBINED
C        OLDSPD - VELOCITY OF PREVIOUS SECOND
C        OLDUR  - ARRAY, OCCURRENCES OF OPEN LOOP BY DURATION
C        OLMODE - ACCEL AND VEL MODE DURING OPEN LOOP
C        OLNUM  - NUMBER OF SECONDS OPEN LOOP
C        OLSPD1 - VELOCITY AT BEGINING OF OPEN LOOP OPERATION
C        OLSPD2 - VELOCITY AT END OF OPEN LOOP OPERATION
C        OMACL  - PERCENT OF MEDIUM ACCEL OCCURRENCES
C        OMDCL  - PERCENT OF MEDIUM DECEL OCCURRENCES
C        ONOSPD - PERCENT OF STOPPED OCCURRENCES
C        OTFLNM - OUTPUT FILE FOR SUMMARY TRACE STATS
C        PCLDTM - LOAD MODE, PERCENT TIME IN COLD START
C        PCRU   - PERCENT TIME IN MODE "CRUISE"
C        PCST   - PERCENT TIME IN MODE "COAST"
C        PCTCOL - PERCENT TIME IN COLD START OPEN LOOP
C        PCTOL  - PERCENT TIME OPEN LOOP
C        PHACL  - PERCENT TIME IN MODE "HARD ACCEL"
C        PHDCL  - PERCENT TIME IN MODE "HARD DECEL"
C        PHOTTM - LOAD MODE, PERCENT TIME IN HOT START
C        PLACL  - PERCENT TIME IN MODE "LIGHT ACCEL"
```

```
C        PLDCL  - PERCENT TIME IN MODE "LIGHT DECEL"
C        PLLD   - LOAD MODE, PERCENT TIME LOW LOAD
C        PLOL   - PERCENT TIME IN LEAN OPEN LOOP OPERATION
C        PMHLD  - LOAD MODE, PERCENT TIME MEDIUM HIGH LOAD
C        PMLLD  - LOAD MODE, PERCENT TIME MEDIUM LOW LOAD
C        PMACL  - PERCENT TIME IN MODE "MEDIUM ACCEL"
C        PMAVG  - AVERAGE PERCENT METHANOL
C        PMDCL  - PERCENT TIME IN MODE "MEDIUM DECEL"
C        PMMAX  - MAXIMUM PERCENT METHANOL
C        PMMIN  - MINIMUM PERCENT METHANOL
C        PMSM   - SUM OF PERCENT METHANOL MEASUREMENTS
C        PNOSPD - PERCENT TIME IN MODE "STOPPED"
C       POLLD  - LOAD MODE, PERCENT TIME OPEN LOOP, LEAN AND RICH COMBINED
C        PROL   - PERCENT TIME IN RICH OPEN LOOP OPERATION
C        R      - NUMBER OF CRUISE OCCURRENCES
C        ROL    - NUMBER OF SECONDS IN RICH OPEN LOOP OPERATION
C        RORL   - ARRAY, RICH OR LEAN FOR OPEN LOOP OCCURRENCES
C        RPMAVG - AVERAGE ENGINE RPM
C        RPMMAX - MAXIMUM ENGINE RPM
C        RPMMIN - MINIMUM ENGINE RPM
C        RPMSM  - SUM OF ENGINE RPM MEASUREMENTS
C        S      - NUMBER OF HARD DECEL OCCURRENCES
C        SAVE   - FLAG FOR WHETHER OR NOT TO CREAT A SAVE FILE
C        SCRU   - SUM TIME IN MODE "CRUISE"
C        SCST   - SUM TIME IN MODE "COAST"
C        SHACL  - SUM TIME IN MODE "HARD ACCEL"
C        SHDCL  - SUM TIME IN MODE "HARD DECEL"
C        SLACL  - SUM TIME IN MODE "LIGHT ACCEL"
C        SLDCL  - SUM TIME IN MODE "LIGHT DECEL"
C        SMACL  - SUM TIME IN MODE "MEDIUM ACCEL"
C        SMDCL  - SUM TIME IN MODE "MEDIUM DECEL"
C        SMFIPW - SUM OF FUEL INJECTOR PULSE WIDTH
C        SNOSPD - SUM TIME IN MODE "STOPPED"
C        STPDST - AVERAGE DISTANCE PER STOP
C        STPDUR - ARRAY, OCCURRENCES OF STOPS BY DURATION
C        SUMLDP - LOAD MODE, SUM OF PERCENTS OF TIME IN EACH MODE
C        SUMMOD - SUM OF PERCENT TIMES OF ALL V&A OPERATING MODES
C        SUMOL  - TOTAL SECONDS OPERATING OPEN LOOP
C        SUMO   - SUM OF OCCURRENCES OF ALL V&A OPERATING MODES
C        SUMOL  - TOTAL SECONDS OPERATING OPEN LOOP
C        SUMP   - SUM OF PERCENT OCCURRENCES OF ALL V&A OPERATING MODES
C        SUMVEL - SUM OF ALL INSTANEOUS VELOCITIES
C        TCRU   - DETERMINES IF STILL IN CRUISE OCCURRENCE
C        TCST   - DETERMINES IF STILL IN COASTING OCCURRENCE
C        THACL  - DETERMINES IF STILL IN HARD ACCEL OCCURRENCE
C        THDCL  - DETERMINES IF STILL IN HARD DECEL OCCURRENCE
C        TLACL  - DETERMINES IF STILL IN LIGHT ACCEL OCCURRENCE
C        TLDCL  - DETERMINES IF STILL IN LIGHT DECEL OCCURRENCE
C        TMACL  - DETERMINES IF STILL IN MEDIUM ACCEL OCCURRENCE
C        TMDCL  - DETERMINES IF STILL IN MEDIUM DECEL OCCURRENCE
C        TNOSPD - DETERMINES IF STILL IN STOP OCCURRENCE
C        TPAVG  - AVERAGE RELATIVE THROTTLE POSISTION
C        TPMAX  - MAXIMUM RELATIVE THROTTLE POSISTION
C        TPMIN  - MINIMUM RELATIVE THROTTLE POSISTION
C        TPSM   - SUM OF RELATIVE THROTTLE POSISTION MEASUREMENTS
C        VAFAVG - AVERAGE STOCK AIR FUEL SENSOR AFR
C        VAFMAX - MAXIMUM STOCK AIR FUEL SENSOR AFR
C        VAFMIN - MINIMUM STOCK AIR FUEL SENSOR AFR
C        VAFSM  - SUM OF STOCK AIR FUEL SENSOR AFR MEASUREMENTS
C        Z      - LOOP COUNTER
C
```

```
C
C        ***********************************************************

C *******  VARIABLE DECLARATION SECTION  *******

      REAL  INSTSP, DIST, PCTOL, STPDST, SUMOL, MIN, OLSPD1, I
      REAL  FUEL, SMFIPW, MPG, SUMVEL, AVGVEL, PCTCOL, CLDSTR
      real  a(400), GMPE, PCTPE
      REAL  SUMO, SUMP, SUMMOD, PROL, PLOL, OLSPD2
      REAL  PLACL, PMACL, PHACL, PLDCL, PMDCL, PHDCL
      REAL  PCRU, PCST, PNOSPD
      REAL  ALACL, AMACL, AHACL, ALDCL, AMDCL, AHDCL
      REAL  ACRU, ANOSPD, ACST, AOLDUR
      REAL  OLACL, OMACL, OHACL, OLDCL, OMDCL, OHDCL
      REAL  OCRU, OCST, ONOSPD, MAXACL, MAXVS, MAXDCL
      REAL  H, M, L, S, D, C, F, R
      REAL  OLVEL(0:100), OLACCL(0:100)

      REAL BKAVG, BKSM, ACAVG, ACSM, TPAVG, TPSM, RPMAVG, RPMSM

      REAL LODAVG, LODSM, VAFAVG, VAFSM, HORAVG, HORSM, PMAVG
      REAL PMSM, ACLAVG, ACLSM, GRAVG, GRSM, AMTAVG, AMTSM, CATSM

      REAL ACTAVG, ACTSM, ECTAVG, ECTSM, EXGAVG, EXGSM, CATAVG
      REAL TPMAX, TPMIN, RPMMAX, RPMMIN, LODMAX, LODMIN, VAFMAX
      REAL VAFMIN, HORMAX, HORMIN, PMMAX, PMMIN, ACLMAX, ACLMIN
      REAL GRMAX, GRMIN, AMTMAX, AMTMIN, ACTMAX, ACTMIN, ECTMAX
      REAL ECTMIN, EXGMAX, EXGMIN, CATMAX, CATMIN
      REAL CSTRT, HSTRT, OLLD, HLD, MHLD, MLLD, LLD, SUMLDP

      REAL PCLDTM, PHOTTM, POLLD, PHLD, PMHLD, PMLLD, PLLD


      INTEGER  B, Z, CUTRPM, CUTTP
      INTEGER  getnum, getlab, OLNUM, NOSPD, ROL, LOL
      INTEGER  OLDUR(0:100),  STPDUR(0:500), CRUDR(0:1000)
      INTEGER  CSTDR(0:500)
      INTEGER  LDCLDR(0:1000), MDCLDR(0:500), HDCLDR(0:500)
      INTEGER  LACLDR(0:1000), MACLDR(0:500), HACLDR(0:500)
      INTEGER  LACL, MACL, HACL, LDCL, MDCL, HDCL, CRUISE
      INTEGER  TLACL, TMACL, THACL, TLDCL, TMDCL, THDCL, TNOSPD
      INTEGER  SLACL, SMACL, SHACL, SLDCL, SMDCL, SHDCL
      INTEGER  TCRU, SCRU, TCST, SCST, SNOSPD, COAST

      CHARACTER*40   INFLNM, OTFLNM, DTFLNM, OLFLNM
      character*400  header
      CHARACTER*1    AORD(0:500), RORL(0:500)
      CHARACTER*1    SAVE, DATFIL
      CHARACTER*2    OLMODE(0:100)

C ############################################
C **********   BEGIN MAIN PROGRAM   ***********
C ############################################

C *******  READ IN FILE NAMES FOR I/O  *******


      READ (*,'(A)') INFLNM
      READ (*,'(A)') OTFLNM
      READ (*,'(A)') OLFLNM
```

```
      READ  (*,'(A)') SAVE
      READ  (*,'(A)') DATFIL
      READ  (*,'(A)') DTFLNM
      OPEN  (3, FILE = INFLNM)
      OPEN  (4, FILE = OTFLNM)
      OPEN  (7, FILE = OLFLNM)
      OPEN  (2, FILE = DTFLNM)


C *****  PRESET VARIABLES TO ZERO  *****

      DIST = 0
      SMFIPW = 0
      SUMSPD = 0
      OLNUM = 0
      CLDSTR = 0
      B = 0
      F = 0
      H = 0
      M = 0
      L = 0
      C = 0
      R = 0
      G = 0
      D = 0
      S = 0
      SUMOL = 0
      NOSPD = 0
      LDCL = 0
      MDCL = 0
      HDCL = 0
      CRUISE = 0
      COAST =0
      LACL = 0
      MACL = 0
      HACL = 0
      TNOSPD = 0
      TLDCL = 0
      TMDCL = 0
      THDCL = 0
      TCRU = 0
      TCST = 0
      TLACL = 0
      TMACL = 0
      THACL = 0
      SNOSPD = 0
      SLDCL = 0
      SMDCL = 0
      SHDCL = 0
      SCRU = 0
      SLACL = 0
      SMACL = 0
      SHACL = 0
      OLDSPD = 0
      OLDUR(0) = 0
      ROL = 0
      LOL = 0
      MAXACL = 0
      MAXVS = 0
      MAXDCL = 0
      BKSM = 0
```

```
      ACSM = 0
      TPSM = 0
      RPMSM = 0
      LODSM = 0
      VAFSM = 0
      HORSM = 0
      PMSM = 0
      ACLSM = 0
      GRSM = 0
      AMTSM = 0
      ACTSM = 0
      ECTSM = 0
      EXGSM = 0
      CATSM = 0
      CSTRT = 0
      HSTRT = 0
      PCLDTM = 0
      PHOTTM = 0
      OLLD = 0
      HLD = 0
      MHLD = 0
      MLLD = 0
      LLD = 0
      cutrpm = 2000
      cuttp  = 270
      GMPE = 0

C **********  BEGIN MAIN CALCULATIONS  ***********

      READ (3,'(a)')header

c get # of channels
      ilen=getnum(header)

c get indices of variables needed
      itime=getlab('time',header)
      irpm=getlab('n',header)
      ispeed=getlab('vs',header)
      iacc=getlab('accflg',header)
      ibrake=getlab('boo_lvl',header)
      iolf=getlab('olflg',header)
      iload=getlab('load',header)
      iect=getlab('ect',header)
      iact=getlab('act',header)
      itp=getlab('tp_rel',header)
      ivlam=getlab('lambse1',header)
      ifpw=getlab('fuelpw1',header)
      ipmeoh=getlab('pm',header)
      iaf=getlab('lambda',header)
      igear=getlab('gr_cm',header)
      iamtmp=getlab('ambient_temp',header)
      iextmp=getlab('pre_cat_temp',header)
      icatmp=getlab('cat_temp',header)
      iaclrm=getlab('accel',header)

      DO 100 I = 1, 1000000, 1

        READ (3,*,END=120)(a(k),k=1,ilen)
```

```
C   *****   DISTANCE TRAVELED, FUEL ECONOMY AND AVERAGE SPEED ANALYSIS
*****

        SUMVEL = SUMVEL + a(ispeed)
        INSTSP = a(ispeed) / 3600
        DIST = DIST + INSTSP
        SMFIPW = SMFIPW + (a(ifpw) * 2.4E-6 * (a(irpm)/60) * 3)

C  **   DIVIDE THE RPM BY TWO BECAUSE ONLY HALF THE CYLINDERS
C  **   FIRE PER REVOLUTION AND 60 TO OBTAIN RPS (PER SECOND)
C  **   FUEL INJECTOR PULSE WIDTH IS RECORDED AS TICKS,
C  **   1 TICK = 2.4E-6 SECONDS.

C  *****  OPERATING PARAMETER CALCULATIONS  *****

      IF (I.EQ.1) THEN
        TPMAX = A(ITP)
        TPMIN = A(ITP)
        RPMMAX = A(IRPM)
        RPMMIN = A(IRPM)
        LODMAX = A(ILOAD)
        LODMIN = A(ILOAD)
        VAFMAX = A(IVLAM)
        VAFMIN = A(IVLAM)
        HORMAX = A(IAF)
        HORMIN = A(IAF)
        PMMAX = A(IPMEOH)
        PMMIN = A(IPMEOH)
        ACLMAX = A(IACLRM)
        ACLMIN = A(IACLRM)
        GRMAX = A(IGEAR)
        GRMIN = A(IGEAR)
        AMTMAX = A(IAMTMP)
        AMTMIN = A(IAMTMP)
        ACTMAX = A(IACT)
        ACTMIN = A(IACT)
        ECTMAX = A(IECT)
        ECTMIN = A(IECT)
        EXGMAX = A(IEXTMP)
        EXGMIN = A(IEXTMP)
        CATMAX = A(ICATMP)
        CATMIN = A(ICATMP)
      ENDIF

      BKSM = A(IBRAKE) + BKSM
      ACSM = A(IACC) + ACSM

      CALL MINMAX(TPSM, A(ITP), TPMAX, TPMIN)

      CALL MINMAX(RPMSM, A(IRPM), RPMMAX, RPMMIN)

      CALL MINMAX(LODSM, A(ILOAD), LODMAX, LODMIN)

      CALL MINMAX(VAFSM, A(IVLAM), VAFMAX, VAFMIN)

      CALL MINMAX(HORSM, A(IAF), HORMAX, HORMIN)

      CALL MINMAX(PMSM, A(IPMEOH), PMMAX, PMMIN)

      CALL MINMAX(ACLSM, A(IACLRM), ACLMAX, ACLMIN)
```

```
      CALL MINMAX(GRSM, A(IGEAR), GRMAX, GRMIN)
      CALL MINMAX(AMTSM, A(IAMTMP), AMTMAX, AMTMIN)
      CALL MINMAX(ACTSM, A(IACT), ACTMAX, ACTMIN)
      CALL MINMAX(ECTSM, A(IECT), ECTMAX, ECTMIN)
      CALL MINMAX(EXGSM, A(IEXTMP), EXGMAX, EXGMIN)
      CALL MINMAX(CATSM, A(ICATMP), CATMAX, CATMIN)
C  *****  OPEN LOOP AND MODAL ANALYSIS  *****
C    ***  OPEN LOOP ANALYSIS  ***
      IF ((I.EQ.1).AND.(A(IOLF).EQ.1)) THEN
        B = -1
        CLDSTR = 1

        IF (I.EQ.1) THEN
          IF (A(IECT).LT.160) THEN
            CSTRT = 1
          ELSE
            HSTRT = 1
          ENDIF
        ENDIF
      ENDIF

      IF (OLNUM.GE.1) THEN
        OLSPD2 = OLDSPD
        IF (OLSPD1.LT.OLSPD2) THEN
          AORD(B+1) = 'A'
        ELSE
          AORD(B+1) = 'D'
        ENDIF
      ENDIF

      IF (A(IOLF).EQ.1) THEN
        IF (OLNUM.EQ.0) OLSPD1 = OLDSPD
        IF (A(IAF).LT.1) THEN
          RORL(B+1) = 'R'
        ELSE
          RORL(B+1) = 'L'
        ENDIF
        OLNUM = OLNUM + 1
      ENDIF

      IF ((OLNUM.GT.0).AND.(A(IOLF).EQ.0)) THEN
        B = B + 1
        OLDUR(B) = OLNUM
        OLVEL(B) = OLSPD1
        OLACCL(B)= (OLSPD2 - OLSPD1) / OLNUM

        IF (LDCL.NE.0) OLMODE(B) = 'LD'
        IF (MDCL.NE.0) OLMODE(B) = 'MD'
        IF (HDCL.NE.0) OLMODE(B) = 'HD'
        IF (LACL.NE.0) OLMODE(B) = 'LA'
        IF (MACL.NE.0) OLMODE(B) = 'MA'
        IF (HACL.NE.0) OLMODE(B) = 'HA'
        IF (CRUISE.NE.0) OLMODE(B) = 'CR'
```

```
          IF (COAST.NE.0) OLMODE(B) = 'CO'
          IF (NOSPD.NE.0) OLMODE(B) = 'ST'
          IF (B.LT.0) OLMODE(B) = 'CS'

          IF (B.GT.0) THEN
            SUMOL = SUMOL + OLNUM
            IF (RORL(B).EQ.'R') THEN
              ROL = ROL + OLNUM
            ELSE
              LOL = LOL + OLNUM
            ENDIF
          ENDIF
          OLNUM = 0
        ENDIF

C     ***  GM ENRICHMENT MODE ANALYSIS  ***

          IF ((A(IRPM).GE.cutrpm).AND.(A(ITP).GE.cuttp)) THEN
            GMPE = GMPE + 1
          ENDIF

C     ***  VELOCITY AND ACCELERATION MODAL ANALYSIS  ***

        IF (I.EQ.1) OLDSPD = A(ISPEED)

        ACCL = A(ISPEED) - OLDSPD

        IF (ACCL.GT.MAXACL) MAXACL = ACCL
        IF (ACCL.LT.MAXDCL) MAXDCL = ACCL
        IF (A(ISPEED).GT.MAXVS) MAXVS = A(ISPEED)

        IF (B.GE.0) THEN

C        *  IDLE  *

        IF ((A(ISPEED).EQ.0).AND.(A(IRPM).GT.0)) THEN
           NOSPD = NOSPD + 1
        ENDIF

C        *  ACCELS  *

        IF (ACCL.GT.(0.3)) THEN
          IF (A(IOLF).EQ.1) THEN
            HACL = HACL + 1
          ELSE
            ACLM = (A(ISPEED) * 0.0385) + 3.54
            IF (ACCL.GT.(ACLM)) THEN
              MACL = MACL + 1
            ELSE
              LACL = LACL + 1
            ENDIF
          ENDIF
        ENDIF

C        *  DECELS AND CRUISE  *

        IF ((A(ISPEED).GT.0).AND.((ACCL.LE.(0.300)).AND.
     >      (ACCL.GE.(-0.300)))) THEN
          IF (A(ITP).GT.1) THEN
            CRUISE = CRUISE + 1
          ELSE
```

```
          COAST = COAST + 1
        ENDIF
      ENDIF

      IF ((ACCL.LT.(-0.300)).AND.(A(ISPEED).GT.0)) THEN
        IF (A(IBRAKE).EQ.0) THEN
          LDCL = LDCL + 1
        ELSE
          IF (A(ISPEED).LE.20) THEN
            IF (ACCL.GT.(-0.4 * (A(ISPEED)))) THEN
            MDCL = MDCL + 1
            ELSE
            HDCL = HDCL + 1
            ENDIF
          ELSE
            IF (ACCL.GT.(-8)) THEN
            MDCL = MDCL + 1
            ELSE
            HDCL = HDCL + 1
            ENDIF
          ENDIF
        ENDIF
      ENDIF

      ENDIF

C  ***  RECORD "EVENTS" AND SUMS  ***

      IF (LDCL.NE.0) THEN
        CALL EVENTS(LDCL, TLDCL, C, LDCLDR(C), SLDCL)
      ENDIF

      IF (MDCL.NE.0) THEN
        CALL EVENTS(MDCL, TMDCL, D, MDCLDR(D), SMDCL)
      ENDIF

      IF (HDCL.NE.0) THEN
        CALL EVENTS(HDCL, THDCL, S, HDCLDR(S), SHDCL)
      ENDIF

      IF (CRUISE.NE.0) THEN
        CALL EVENTS(CRUISE, TCRU, R, CRUDR(R), SCRU)
      ENDIF

      IF (COAST.NE.0) THEN
        CALL EVENTS(COAST, TCST, G, CSTDR(G), SCST)
      ENDIF

      IF (HACL.NE.0) THEN
        CALL EVENTS(HACL, THACL, H, HACLDR(H), SHACL)
      ENDIF

      IF (MACL.NE.0) THEN
        CALL EVENTS(MACL, TMACL, M, MACLDR(M), SMACL)
      ENDIF

      IF (LACL.NE.0) THEN
        CALL EVENTS(LACL, TLACL, L, LACLDR(L), SLACL)
      ENDIF

      IF (NOSPD.NE.0) THEN
```

```
         CALL EVENTS(NOSPD, TNOSPD, F, STPDUR(F), SNOSPD)
       ENDIF

C        *  SET OLD SPEED FOR ACCELERATION CALCULATION  *

       OLDSPD = A(ISPEED)

C   **  LOAD BASED MODAL ANALYSIS  *****

       IF (B.GE.0) THEN
         IF (A(IOLF).EQ.1) THEN
           OLLD = OLLD + 1
         ELSE
           IF (A(ILOAD).GT.(0.65)) HLD = HLD + 1
           IF ((A(ISPEED).GT.(40)).AND.(A(ILOAD).LE.(0.65))) THEN
             MHLD = MHLD + 1
           ENDIF
           IF ((A(ISPEED).LE.(40)).AND.(A(ILOAD).LE.(0.65)).AND.
     >          (A(ILOAD).GT.(0.40))) THEN
             MLLD = MLLD + 1
           ENDIF
           IF ((A(ISPEED).LE.(40)).AND.(A(ILOAD).LE.(0.40))) THEN
             LLD = LLD + 1
           ENDIF
         ENDIF
       ENDIF

C   *****  END OPEN LOOP AND MODAL ANALYSIS  *****

100      CONTINUE
120      CONTINUE

C   *****  CHECK TO SEE IF OPEN LOOP AT END OF RUN  *****

       IF (OLNUM.GT.0) THEN
         B = B + 1
         OLDUR(B) = OLNUM
         OLVEL(B) = OLSPD1
         OLACCL(B)= (OLSPD2 - OLSPD1) / OLNUM

         IF (LDCL.NE.0) OLMODE(B) = 'LD'
         IF (MDCL.NE.0) OLMODE(B) = 'MD'
         IF (HDCL.NE.0) OLMODE(B) = 'HD'
         IF (LACL.NE.0) OLMODE(B) = 'LA'
         IF (MACL.NE.0) OLMODE(B) = 'MA'
         IF (HACL.NE.0) OLMODE(B) = 'HA'
         IF (CRUISE.NE.0) OLMODE(B) = 'CR'
         IF (COAST.NE.0) OLMODE(B) = 'CO'
         IF (NOSPD.NE.0) OLMODE(B) = 'ST'
         IF (B.LT.0) OLMODE(B) = 'CS'

         IF (B.GT.0) THEN
           SUMOL = SUMOL + OLNUM
           IF (RORL(B).EQ.'R') THEN
             ROL = ROL + OLNUM
           ELSE
             LOL = LOL + OLNUM
           ENDIF
         ENDIF
       ENDIF
```

```
C   *****  DISTANCE TRAVELED, FUEL ECONOMY AND AVERAGE SPEED STATS   *****

      FUEL = SMFIPW * 1.129E-3

C       BASED ON 25 LBS M0 PER HR (1.129E-3 GAL PER SECOND)

      MPG = DIST / FUEL
      AVGVEL = SUMVEL / (I-1)

      MIN = I/60

C   *****  OPERATING PARAMETER CALCULATIONS   *****

      BKAVG =  (BKSM / I) * 100
      ACAVG =  (ACSM / I) * 100
      TPAVG =  TPSM / I
      RPMAVG = RPMSM / I
      LODAVG = LODSM / I
      VAFAVG = VAFSM / I
      HORAVG = HORSM / I
      PMAVG =  PMSM / I
      ACLAVG = ACLSM / I
      GRAVG =  GRSM / I
      AMTAVG = AMTSM / I
      ACTAVG = ACTSM / I
      ECTAVG = ECTSM / I
      EXGAVG = EXGSM / I
      CATAVG = CATSM / I


C   *****  OPEN LOOP AND MODAL SUMMARY CALCULATIONS   *****

      IF (LDCL.NE.0) THEN
        CALL SUMMARY(C, LDCLDR(C), LDCL, SLDCL)
      ELSEIF (MDCL.NE.0) THEN
        CALL SUMMARY(D, MDCLDR(D), MDCL, SMDCL)
      ELSEIF (HDCL.NE.0) THEN
        CALL SUMMARY(S, HDCLDR(S), HDCL, SHDCL)
      ELSEIF (CRUISE.NE.0) THEN
        CALL SUMMARY(R, CRUDR(R), CRUISE, SCRU)
      ELSEIF (COAST.NE.0) THEN
        CALL SUMMARY(G, CSTDR(G), COAST, SCST)
      ELSEIF (HACL.NE.0) THEN
        CALL SUMMARY(H, HACLDR(H), HACL, SHACL)
      ELSEIF (MACL.NE.0) THEN
        CALL SUMMARY(M, MACLDR(M), MACL, SMACL)
      ELSEIF (LACL.NE.0) THEN
        CALL SUMMARY(L, LACLDR(L), LACL, SLACL)
      ELSEIF (NOSPD.NE.0) THEN
        CALL SUMMARY(F, STPDUR(F), NOSPD, SNOSPD)
      ENDIF

C   *****  OPEN LOOP AND A&V MODAL ANALYSIS STATS   *****

      PCTOL  = (SUMOL*100)/(I-1)
      PROL   = (ROL*100)/(I-1)
      PLOL   = (LOL*100)/(I-1)
      PCTCOL = (OLDUR(0)*100)/(I-1)
      PHACL  =  (SHACL*100)/(I-1)
      PMACL  =  (SMACL*100)/(I-1)
```

```
 PLACL  =  (SLACL*100)/(I-1)
 PHDCL  =  (SHDCL*100)/(I-1)
 PMDCL  =  (SMDCL*100)/(I-1)
 PLDCL  =  (SLDCL*100)/(I-1)
 PCRU   =  (SCRU*100)/(I-1)
 PCST   =  (SCST*100)/(I-1)
 PNOSPD =  (SNOSPD*100)/(I-1)

 SUMP = PHACL + PMACL + PLACL + PHDCL + PMDCL + PLDCL +
>          PCRU + PNOSPD + PCST + PCTCOL

 SUMMOD = H + M + L + S + D + C + F + R + G + CLDSTR

 OCLDST =  (CLDSTR*100)/SUMMOD
 OHACL  =  (H*100)/SUMMOD
 OMACL  =  (M*100)/SUMMOD
 OLACL  =  (L*100)/SUMMOD
 OHDCL  =  (S*100)/SUMMOD
 OMDCL  =  (D*100)/SUMMOD
 OLDCL  =  (C*100)/SUMMOD
 OCRU   =  (R*100)/SUMMOD
 OCST   =  (G*100)/SUMMOD
 ONOSPD =  (F*100)/SUMMOD

 SUMO = OHACL + OMACL + OLACL + OHDCL + OMDCL + OLDCL +
>          OCRU + ONOSPD + OCST + OCLDST

 AOLDUR = OLDUR(0)
 IF (H.EQ.0) THEN
   AHACL = 0
 ELSE
   AHACL  = (SHACL)/H
 ENDIF
 IF (M.EQ.0) THEN
   AMACL = 0
 ELSE
   AMACL  = (SMACL)/M
 ENDIF
 IF (L.EQ.0) THEN
   ALACL = 0
 ELSE
   ALACL  = (SLACL)/L
 ENDIF
 IF (S.EQ.0) THEN
   AHDCL = 0
 ELSE
   AHDCL  = (SHDCL)/S
 ENDIF
 IF (D.EQ.0) THEN
   AMDCL = 0
 ELSE
   AMDCL  = (SMDCL)/D
 ENDIF
 IF (C.EQ.0) THEN
   ALDCL = 0
 ELSE
   ALDCL  = (SLDCL)/C
 ENDIF
 IF (R.EQ.0) THEN
   ACRU = 0
 ELSE
```

```
          ACRU    = (SCRU)/R
        ENDIF
        IF (G.EQ.0) THEN
          ACST = 0
        ELSE
          ACST    = (SCST)/G
        ENDIF
        IF (F.EQ.0) THEN
          ANOSPD = 0
        ELSE
          ANOSPD = (SNOSPD)/F
        ENDIF

        IF (F.NE.0) STPDST = DIST / F
        ELSE STPDST = 0

C  *****  LOAD BASED MODAL ANALYSIS STATS  *****

        IF (CSTRT.GT.0)   PCLDTM   =   (OLDUR(0)*100)/(I-1)
        IF (HSTRT.GT.0)   PHOTTM   =   (OLDUR(0)*100)/(I-1)
        POLLD   =   (OLLD*100)/(I-1)
        PHLD    =   (HLD*100)/(I-1)
        PMHLD   =   (MHLD*100)/(I-1)
        PMLLD   =   (MLLD*100)/(I-1)
        PLLD    =   (LLD*100)/(I-1)

        SUMLDP = PCLDTM + PHOTTM + POLLD + PHLD +
     >            PMHLD + PMLLD + PLLD


C   *****  CALCULATE PERCENT TIME IN GM ENRICHMENT MODE   *****

        PCTPE = 100 * GMPE / (I-1)


C   *****  WRITE RESULTS TO OUTFILE  *****

        IF ((DATFIL.EQ.'Y').OR.(DATFIL.EQ.'y')) THEN
        WRITE (4,'(A40)') inflnm
        ENDIF
        WRITE (4,*) ' '
        WRITE (4,*) ' '
        WRITE (4,*) ' '
        WRITE (4,*) ' '
        WRITE (4,*) '__________________________________________________',
     >          '____________________________'
        WRITE (4,*) '__________________________________________________',
     >          '____________________________'
        WRITE (4,*) ' '
        WRITE (4,*) 'Calculated data from recorded data files: '
        WRITE (4,*) ' '
        WRITE (4,*) '----------------------------------------',
     >          '---------------------'
        WRITE (4,*) ' '
        WRITE (4,229) MIN
229       FORMAT (' Time of travel =       ', F6.2, ' minutes.')
        WRITE (4,*) ' '
        WRITE (4,230) DIST
230       FORMAT (' Distance traveled =    ', F6.2, ' miles.')
        WRITE (4,*) ' '
        WRITE (4,240) AVGVEL
```

```
240     FORMAT (' Average velocity =      ', F6.2, ' MPH.')
      WRITE (4,*) '  '
      WRITE (4,243) MAXVS
243     FORMAT (' Maximum velocity =      ', F6.2, ' MPH.')
      WRITE (4,*) '  '
      WRITE (4,246) MAXACL
246     FORMAT (' Maximum Acceleration = ', F6.2, ' MPH s-1.')
      WRITE (4,*) '  '
      WRITE (4,248) MAXDCL
248     FORMAT (' Maximum Deceleration = ', F6.2, ' MPH s-1.')
      WRITE (4,*) '  '
      WRITE (4,250) MPG
250     FORMAT (' Fuel economy =          ', F6.2, ' mpg.')
      WRITE (4,*) '  '
      WRITE (4,*) '_____________________________________________',
     >            '______________________'
      WRITE (4,*) '_____________________________________________',
     >            '______________________'
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      IF ((DATFIL.NE.'Y').OR.(DATFIL.NE.'y')) THEN
        WRITE (4,255) inflnm
255       FORMAT ('                               Page 1 - ', A12)
      ENDIF
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) 'Velocity and acceleration modal analysis:  '
      WRITE (4,*) '  '
      WRITE (4,*) 'Mode          Number of    Percent of     ',
     >            'Percent    Average'
      WRITE (4,*) '              Occurrences  Occurrences    ',
     >            ' time       time'
      WRITE (4,*) '---------------------------------------------',
     >            '----------------------'
      WRITE (4,400) 'Start       : ', CLDSTR, OCLDST, PCTCOL, AOLDUR
      WRITE (4,400) 'Stopped     : ', F, ONOSPD, PNOSPD, ANOSPD
      WRITE (4,400) 'Cruise      : ', R, OCRU, PCRU, ACRU
      WRITE (4,400) 'Coast       : ', G, OCST, PCST, ACST
      WRITE (4,400) 'Hard Accl   : ', H, OHACL, PHACL, AHACL
      WRITE (4,400) 'Med Accl    : ', M, OMACL, PMACL, AMACL
      WRITE (4,400) 'Light Accl  : ', L, OLACL, PLACL, ALACL
      WRITE (4,400) 'Hard Decl   : ', S, OHDCL, PHDCL, AHDCL
      WRITE (4,400) 'Med Decl    : ', D, OMDCL, PMDCL, AMDCL
      WRITE (4,400) 'Light Decl  : ', C, OLDCL, PLDCL, ALDCL
      WRITE (4,*) '  '
      WRITE (4,450) 'Totals      : ', SUMMOD, SUMO, SUMP
400     FORMAT (' ', A13, F8.0, F14.2, F13.2, F11.2)
450     FORMAT (' ', A13, F8.0, F14.2, F13.2)
      IF (F.GT.0) THEN
        WRITE (4,500)  STPDST
500       FORMAT (' Average distance between stops: ', F6.2, ' miles.')
      ELSE
        WRITE (4,*) '  '
      ENDIF
      WRITE (4,*) '  '
      WRITE (4,*) '_____________________________________________',
     >            '______________________'
```

```
      WRITE (4,*) '____________________________________________',
     >       '_______________________'
      WRITE (4,*) ' '
      WRITE (4,*) 'Vehicle operating parameter analysis:  '
      WRITE (4,*) '  '
      WRITE (4,*) 'Parameter                       Average ',
     >       '      Maximum      Minimum '
      WRITE (4,*) '--------------------------------------------',
     >       '-----------------------'
      WRITE (4,430) 'Throttle Position : ', tpavg, tpmax, tpmin
      WRITE (4,430) 'RPM               : ', rpmavg, rpmmax, rpmmin
      WRITE (4,430) 'Load              : ', lodavg, lodmax, lodmin
      WRITE (4,430) 'Vehicle A/F       : ', vafavg, vafmax, vafmin
      WRITE (4,430) 'Horiba A/F        : ', horavg, hormax, hormin
      WRITE (4,430) 'Percent MeOH      : ', pmavg, pmmax, pmmin
      WRITE (4,430) 'Acelerometer      : ', aclavg, aclmax, aclmin
      WRITE (4,430) 'Gear              : ', gravg, grmax, grmin
      WRITE (4,430) 'Ambient Temp      : ', amtavg, amtmax, amtmin
      WRITE (4,430) 'Air Charge Temp   : ', actavg, actmax, actmin
      WRITE (4,430) 'Eng Coolant Temp  : ', ectavg, ectmax, ectmin
      WRITE (4,430) 'Exhast Gas Temp   : ', exgavg, exgmax, exgmin
      WRITE (4,430) 'Catalyst Temp     : ', catavg, catmax, catmin
      WRITE (4,*) '  '
      WRITE (4,440) 'Percent time braking:     ', bkavg
      WRITE (4,440) 'Percent time with A/C on: ', acavg
430     FORMAT (' ', A20, F14.2, F13.2, F13.2)
440     FORMAT (' ', A26, F8.2)
      WRITE (4,*) '____________________________________________',
     >       '_______________________'
      WRITE (4,*) '____________________________________________',
     >       '_______________________'
      WRITE (4,*) '  '
      WRITE (4,*) 'Load based modal analysis:  '
      WRITE (4,*) '  '
      WRITE (4,*) '  Mode                              Percent of time'
      WRITE (4,*) '--------------------------------------------',
     >       '-----------------------'
      WRITE (4,410) '1. Open loop (rich & lean) : ', POLLD
      WRITE (4,410) '2. High load               : ', PHLD
      WRITE (4,410) '3. Medium high load        : ', PMHLD
      WRITE (4,410) '4. Medium low load         : ', PMLLD
      WRITE (4,410) '5. Low load                : ', PLLD
      WRITE (4,410) '6. Hot Start               : ', PHOTTM
      WRITE (4,410) '7. Cold Start              : ', PCLDTM
      WRITE (4,*) '  '
      WRITE (4,420) 'Total                      : ', SUMLDP
410     FORMAT (' ', A31, F8.2)
420     FORMAT (' ', A31, F8.2)
      WRITE (4,*) '  '
      WRITE (4,*) ' '
      IF ((DATFIL.NE.'Y').OR.(DATFIL.NE.'y')) THEN
        WRITE (4,256) inflnm
256       FORMAT ('                             Page 2 - ', A12)
      ENDIF
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) '____________________________________________',
     >       '_______________________'
      WRITE (4,*) '____________________________________________',
     >       '_______________________'
```

```
      WRITE (4,*) ' '
      WRITE (4,*) 'Open loop and GM enrichment operation analysis:'
      WRITE (4,*) ' '
      IF (CLDSTR.EQ.1) THEN
        WRITE (4,*) 'Start (cold or hot) WAS present.'
        WRITE (4,270)  PCTCOL
270       FORMAT (' Percent time in start open loop: '
     >            , F9.6, '%.')
        WRITE (4,*) 'Excluding start:  '
        WRITE (4,280)  PCTOL
280       FORMAT ('   Percent time open loop:     ', F8.6, '%.')
      ELSE
        WRITE (4,*) 'Start was NOT present.'
      ENDIF
      WRITE (4,310)  PROL
310     FORMAT ('   Percent time RICH open loop: ', F8.6, '%.')
      WRITE (4,315)  PLOL
315     FORMAT ('   Percent time LEAN open loop: ', F8.6, '%.')
      WRITE (4,*) ' '
      WRITE (4,*) ' Occurrences of GM enrichment mode:  '
      WRITE (4,*) ' Percent  Number  Total Sec '
      WRITE (4,360) PCTPE, GMPE, I-1
360        FORMAT (F8.3, F8.0, F10.0)
      WRITE (4,*) ' '
      IF (CLDSTR.EQ.0) THEN
        WRITE (4,320) B
      ELSE
        WRITE (4,320) (B+1)
      ENDIF
320     FORMAT (' Open loop occurences: ', I3)
      WRITE (4,*) ' '
      IF (B.GT.0) THEN
        WRITE (4,*) 'Occurences (seconds, accel/decel, rich/lean,',
     >               ' mode, velocity, accel)'
        WRITE (4,*) ' '
        WRITE (4,340) (OLDUR(Z), AORD(Z), RORL(Z), OLMODE(Z),
     >    OLVEL(Z), OLACCL(Z),  Z = 1, B, 1)
340       FORMAT (1(I4,'  ',A1,'  ',A1,'  mode = ',A2,
     >        '  vel =',F6.2,'  accl =',F6.2))
        WRITE (7,350) (OLDUR(Z), RORL(Z),
     >    OLVEL(Z), OLACCL(Z),  Z = 1, B, 1)
350       FORMAT (1(I4,'  ', A1, F7.2, F7.2))
      ENDIF
      WRITE (4,*) ' '
      WRITE (4,*) '_______________________________________________',
     >    '_______________________'
      WRITE (4,*) '_______________________________________________',
     >    '_______________________'
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      IF ((DATFIL.NE.'Y').OR.(DATFIL.NE.'y')) THEN
        WRITE (4,257) inflnm
257       FORMAT ('                                Page 3 - ', A12)
      ENDIF

C   *****  WRITE RAW MODE OCCURENCES TO OUTPUT SAVE FILE  *****

      IF ((SAVE.EQ.'Y').OR.(SAVE.EQ.'y')) THEN
```

```
WRITE (2,*) ' '
IF (CLDSTR.EQ.0) THEN
  WRITE (2,*) '-999'
ELSE
  WRITE (2,22) OLDUR(0)
ENDIF
WRITE (2,*) ' '
IF (F.EQ.0) THEN
  WRITE (2,*) '-999'
ELSE
  WRITE (2,22) (STPDUR(Z), Z = 1, F, 1)
ENDIF
WRITE (2,*) ' '
IF (R.EQ.0) THEN
  WRITE (2,*) '-999'
ELSE
  WRITE (2,22) (CRUDR(Z), Z = 1, R, 1)
ENDIF
WRITE (2,*) ' '
IF (G.EQ.0) THEN
  WRITE (2,*) '-999'
ELSE
  WRITE (2,22) (CSTDR(Z), Z = 1, G, 1)
ENDIF
WRITE (2,*) ' '
IF (H.EQ.0) THEN
  WRITE (2,*) '-999'
ELSE
  WRITE (2,22) (HACLDR(Z), Z = 1, H, 1)
ENDIF
WRITE (2,*) ' '
IF (M.EQ.0) THEN
  WRITE (2,*) '-999'
ELSE
  WRITE (2,22) (MACLDR(Z), Z = 1, M, 1)
ENDIF
WRITE (2,*) ' '
IF (L.EQ.0) THEN
  WRITE (2,*) '-999'
ELSE
  WRITE (2,22) (LACLDR(Z), Z = 1, L, 1)
ENDIF
WRITE (2,*) ' '
IF (S.EQ.0) THEN
  WRITE (2,*) '-999'
ELSE
  WRITE (2,22) (HDCLDR(Z), Z = 1, S, 1)
ENDIF
WRITE (2,*) ' '
IF (D.EQ.0) THEN
  WRITE (2,*) '-999'
ELSE
  WRITE (2,22) (MDCLDR(Z), Z = 1, D, 1)
ENDIF
WRITE (2,*) ' '
IF (C.EQ.0) THEN
  WRITE (2,*) '-999'
ELSE
  WRITE (2,22) (LDCLDR(Z), Z = 1, C, 1)
ENDIF
```

```
      WRITE (2,*) ' '

22      FORMAT (15I4)
      WRITE (2,*) '  '
      ENDIF

C  *****   END THE MAIN PROGRAM   *****

      END


C  *****   FUNCTIONS   *****

c  by G. Jesion, Ford Motor Company
c  Copyrite, 1991

      integer function getlab(lab,list)
      character *(*) lab,list
      character*20 test

      index=1
      do i=1,40
        test='                    '
        do j=1,40
          if(list(index:index).EQ.' ') then
            do k=1,40
            if(list(index:index).NE.' ') go to 10
            index=index+1
            enddo
          endif
          test(j:j)=list(index:index)
          index=index+1
        enddo
10        continue
        if(test.EQ.lab) then
          getlab=i
          return
        endif
      enddo
      print *,lab,' not found!'
      stop
      return
      end

      integer function getnum(t)
      character*(*) t
      index=1
      iword=0
      isspace=1
      do i=1,400
        if(t(index:index).NE.' ') then
          isspace=0
        else
          if(isspace.EQ.0) then
            iword=iword+1
            isspace=1
          endif
        endif
        index=index+1
      enddo
      getnum=iword
```

```
      return
      end

C  *****   SUBROUTINES   *****

      SUBROUTINE MINMAX(SUM, VAL, MAX, MIN)

      REAL SUM, VAL, MAX, MIN

      SUM = VAL + SUM
      IF (VAL.GT.MAX) MAX = VAL
      IF (VAL.LT.MIN) MIN = VAL

      RETURN
      END


      SUBROUTINE EVENTS(MD, TMD, CNT, MDDR, SMD)
      INTEGER  MD, TMD, SMD, MDDR
      REAL     CNT

      IF (MD.NE.TMD) THEN
      TMD = MD
      ELSE
      CNT = CNT + 1
      MDDR = MD
      SMD = MD + SMD
      MD = 0
      TMD = 0
      ENDIF

      RETURN
      END

      SUBROUTINE SUMMARY(CNT, MDDR, MD, SMD)

      INTEGER  MD, SMD, MDDR
      REAL     CNT

      CNT = CNT + 1
      MDDR = MD
      SMD = MD + SMD

      RETURN
      END

C  *****   END THE PROGRAM   *****
```

A.1.2 Velocity and Acceleration Probability Binning Program VABINEW1.FOR

```
C        PROGRAM VABINEW1 (VELOCITY AND ACCELERATION BIN PROGRAM)
C        MARCH 3, 1993   VER. 1.0
C
C        ********************************************************
C
C      THIS PROGRAM WRITTEN BY:
C          MICHAEL J. ST. DENIS
C          ATMOSPHERIC INNOVATIVE RESEARCH
C          5025 DENNY AVENUE, #6
C          NORTH HOLLYWOOD, CA 91601
C          (818) 761-6048
C
C      WRITTEN FOR AND PROPERTY OF:
C          THE SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
C          21865 EAST COPELY DRIVE
C          DIAMOND BAR, CA 91765
C
C        ********************************************************
C
C      THIS PROGRAM READS IN VDAS DATA FILE WHICH HAS BEEN CONVERTED TO
C      ASCII WITH THE PROGRAM V5CVT AND BINS THE DATA INTO PROBABILITY
C      BINS BASED ON VELOCITY AND ACCELERATION OF THE VEHICLE.  THE
C      FIRST SECTION OF THE PROGRAM SETS THE LIMITS AND RESOLUTION OF
C      THE BINS TO BE CALCULATED.
C
C        ********************************************************
C
C      VARIABLE DECLARATION SECTION:
C
C      a(???)      - ARRAY OF VARIABLE ???
C      abin        - ACCELERATION BIN WIDTH, MPH S-1
C      accl        - CALCULATED ACCELERATION, MPH S-1
C      amax        - MAXIMUM ACCELERATION FOR BINS, MPH S-1
C      amin        - MINIMUM ACCELERATION FOR BINS, MPH S-1
C      f           - VELOCITY LOOP COUNTER TO PRESET TO ZERO
C      getnum      - FUNCTION, NUMBER OF CHANNELS IN DATA FILE
C      getlab      - FUNCTION, INDICIES OF VARIABLES IN DATA FILE
C      header      - ARRAY, CONTAINS HEADER INFO FROM INPUT FILE
C      I           - LOOP COUNTER
C      m           - "VA" ARRAY ACCELERATION COUNTER
C      n           - "VA" ARRAY VELOCITY COUNTER
C      s           - ACCELERATION LOOP COUNTER TO PRESET TO ZERO
C      va(??,??)   - VELOCITY AND ACCELERATION ARRAY
C      vbin        - VELOCITY BIN WIDTH, MPH
C      vel1        - FIRST VELOCITY READ IN
C      vel2        - SECOND VELOCITY READ IN
C      vmax        - MAXIMUM VELOCITY FOR BINS, MPH
C      vmin        - MINIMUM VELOCITY FOR BINS, MPH
C      x           - "VA" ARRAY VELOCITY COUNTER FOR WRITE
C      z           - "VA" ARRAY ACCELERATION COUNTER FOR WRITE
C
C   *******************************************************
C

C   ********  VARIABLE DECLARATION SECATION  ***************

       REAL  I, vbin, abin, vmin, vmax, amin, amax
```

```
      REAL  a(400), s, f, m, n, x,z
      REAL  va(100,100), accl, vel1, vel2

      INTEGER  getnum, getlab

      CHARACTER*400  header

C   *****************  BEGIN MAIN PROGRAM  **************

      vbin = 1
      vmin = -0.5
      vmax = 90
      abin = 1
      amin = -10.5
      amax = 10.5


      do 15 s = amin, amax, vbin
        do 10 f = vmin, vmax, abin
          va(s,f) = 0
10        continue
15      continue

      READ (*,'(a)')header

c get # of channels
      ilen=getnum(header)

c get indice of variable needed
      ispeed=getlab('vs',header)

      DO 100 I = 0, 100000000, 1

        READ (*,*,END=120)(a(k),k=1,ilen)

        if (i.EQ.0) vel1 = a(ispeed)
        vel2 = vel1
        vel1 = a(ispeed)
        accl = vel1 - vel2

        do 300 n = amin, (amax - abin), abin
          if ((accl.gt.(n)).and.(accl.le.(n+abin))) then
            do 200 m = vmin, (vmax - vbin), vbin
            if ((vel1.ge.(m)).and.(vel1.lt.(m+vbin))) then
              va(n,m) = va(n,m) + 1
            endif
200           continue
          endif
300       continue
100     continue
120     continue

C   **************  OUTPUT SECTION  ********************

      do 500 z = vmin, (vmax - vbin), vbin
        do 400 x = amin, (amax - abin), abin
          write (*,550)  (z + (vbin/2)), (x + (abin/2)),
     >          (va(x,z)/I) * 100
400       continue
500     continue
```

```
550     format (F7.2, F7.2, F14.10)

      END

C  ******************  END MAIN PROGRAM  **********************


C  *****   FUNCTIONS  *****

c  by G. Jesion, Ford Motor Company
c  Copyrite, 1991

      integer function getlab(lab,list)
      character *(*) lab,list
      character*20 test

      index=1
      do i=1,40
        test='                    '
        do j=1,40
          if(list(index:index).EQ.' ') then
            do k=1,40
            if(list(index:index).NE.' ') go to 10
            index=index+1
            enddo
          endif
          test(j:j)=list(index:index)
          index=index+1
        enddo
10        continue
        if(test.EQ.lab) then
          getlab=i
          return
        endif
      enddo
      print *,lab,' not found!'
      stop
      return
      end

      integer function getnum(t)
      character*(*) t
      index=1
      iword=0
      isspace=1
      do i=1,400
        if(t(index:index).NE.' ') then
          isspace=0
        else
          if(isspace.EQ.0) then
            iword=iword+1
            isspace=1
          endif
        endif
        index=index+1
      enddo
      getnum=iword
      return
      end
```

```
C   *************************   END   ***************************
```

A.2 Emissions Modeling Programs

The source codes for the VDAS data analysis programs are listed in the following sections.

A.2.1 Acceleration and Speed-based Emissions Binning Program EMMODE.FOR

```
C ********************************************************************
C
C     PROGRAM EMMODE (EMISSIONS BINING PROGRAM BASED ON VEL AND ACCL
C                    MODES)
C     JANUARY 26, 1993    VER. 1.0
C
C ********************************************************************
C
C     THIS PROGRAM WRITTEN BY:
C         MICHAEL J. ST. DENIS
C         ATMOSPHERIC INNOVATIVE RESEARCH
C         5025 DENNY AVENUE, #6
C         NORTH HOLLYWOOD, CA 91601
C         (818) 761-6048
C
C     WRITTEN FOR AND PROPERTY OF:
C         THE SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
C         21865 EAST COPELY DRIVE
C         DIAMOND BAR, CA 91765
C
C ********************************************************************
C
C     THIS PROGRAM READS IN A .DRW DATA FILE WHICH HAS BEEN
C     CONVERTED TO AN .AEU DATA FILE (ASCII) BY THE PROGRAM
C     V5CVT.EXE, AND CALCULATES THE MODE THE VEHICLE IS IN
C     AND FROM THE EMISSIONS FILE DETERMINE THE EMISSIONS OF
C     HC, CO, AND NOX AND ASSIGNS THEM TO THE MODE.  THE
C     AVERAGE EMISSIONS FOR EACH MODE IS THEN CALCULATED AND
C     WRITTEN TO A FILE FOR VIEWING AND ANOTHER FOR USE IN EMISSIONS
C     MODELING.
C
C ********************************************************************
C
C     VARIABLE DECLARATION SECTION:
C
C
C     VARIABLE ARRAYS ARE DEFINED AS FOLLOWS...
C
C         RT(X,Y)  WHERE...
C
C         R = EMISSIONS COMPOUND
C           H - HYDROCARBON
C           C - CARBON MONOXIDE
C           N - OXIDES OF NITROGEN
C
C         T = VARIABLE TYPE
C           N - SAMPLE NUMBER
C           S - SUM
C           Q - SUM OF SQUARES
C           A - AVERAGE
C           D - STANDARD DEVIATION
C
C         X = VEL AND ACCL BASED MODES
C           0 - STOPPED
C           1 - START
C           2 - COAST
C           3 - CRUISE
```

```
C          4 - LIGHT ACCEL
C          5 - MEDIUM ACCEL
C          6 - HARD ACCEL
C          7 - LIGHT DECEL
C          8 - MEDIUM DECEL
C          9 - HARD DECEL
C
C        Y = VELOCITY RANGE
C          0 - 0  TO 10 MPH
C          1 - 10 TO 20 MPH
C          2 - 20 TO 30 MPH
C          3 - 30 TO 40 MPH
C          4 - 40 TO 50 MPH
C          5 - 50 TO 60 MPH
C          6 - 60 TO 70 MPH
C          7 - 70 MPH PLUS
C
C     OTHER VARIABLES
C
C      HCMASS - MASS HYDROCARBON READ IN
C      COMASS - MASS CARBON MONOXIDE READ IN
C      NOMASS - MASS NOx READ IN
C
C      VDASIN - FILE WITH VDAS DATA
C      EMISIN - FILE WITH EMISSIONS DATA
C      EMISOT - FILE TO WRITE FOR VIEWING
C      EMISMD - FILE TO WRITE AS INPUT TO EMISSIONS PREDICTING MODEL
C
C ********************************************************************


C *************  VARIABLE DECLARATION SECTION  ****************

      REAL  HN(0:9,0:7), HS(0:9,0:7), HQ(0:9,0:7)
      REAL  HA(0:9,0:7), HD(0:9,0:7)
      REAL  CN(0:9,0:7), CS(0:9,0:7), CQ(0:9,0:7)
      REAL  CA(0:9,0:7), CD(0:9,0:7)
      REAL  NN(0:9,0:7), NS(0:9,0:7), NQ(0:9,0:7)
      REAL  NA(0:9,0:7), ND(0:9,0:7)

      REAL  HCMASS, COMASS, NOMASS

      REAL  I, ACLM
      real  a(400)

      INTEGER  B, Z
      INTEGER  getnum, getlab, VB

      CHARACTER*40   VDASIN, EMISIN, EMISOT, EMISMD
      character*400  header

C ********************************************************************
C      ******************  BEGIN MAIN PROGRAM  ****************
C ********************************************************************

C ************  READ IN FILE NAMES FOR I/O  ************


      READ (*,'(A)') VDASIN
      READ (*,'(A)') EMISIN
      READ (*,'(A)') EMISOT
```

```
      READ (*,'(A)') EMISMD
      OPEN (3, FILE = VDASIN)
      OPEN (7, FILE = EMISIN)
      OPEN (4, FILE = EMISOT)
      OPEN (2, FILE = EMISMD)

C ********** PRESET ARRAY VARIABLES TO ZERO ***************

      B = 0

      DO 20 M = 0, 9, 1
       DO 10 V = 0, 7, 1

      HN(M,V)=0
      HS(M,V)=0
      HQ(M,V)=0
      HD(M,V)=-9.999
      CN(M,V)=0
      CS(M,V)=0
      CQ(M,V)=0
      CD(M,V)=-9.999
      NN(M,V)=0
      NS(M,V)=0
      NQ(M,V)=0
      ND(M,V)=-9.999

10    CONTINUE
20    CONTINUE

C *************** BEGIN MAIN CALCULATIONS ****************

      READ (3,'(a)')header

c get # of channels
      ilen=getnum(header)

c get indices of variables needed
      irpm=getlab('n',header)
      ispeed=getlab('vs',header)
      ibrake=getlab('boo_lvl',header)
      iolf=getlab('olflg',header)
      itp=getlab('tp_rel',header)

      DO 100 I = 1, 1000000, 1

C ****************** READ IN THE VDAS DATA AND ******************
C **************** READ IN THE MASS OF EMISSIONS *****************

      READ (3,*,END=120) (a(k),k=1,ilen)
      READ (7,80,END=120) HCMASS, COMASS, NOMASS
80      FORMAT (T37,F5.0,T60,F5.0,T83,F5.0)

C ************* VEL AND ACCL BASED MODAL ANALYSIS **************

      IF (I.EQ.1) OLDSPD = A(ISPEED)

      ACCL = A(ISPEED) - OLDSPD

C ********** START **********

      IF (((I.EQ.1).AND.(A(IOLF).EQ.1)).OR.((B.EQ.-1).AND.
```

```
     >   (A(IOLF).EQ.1))) THEN

         Y = 1

         Z = VB(A(ISPEED))

         B = -1
       ELSE
         B = 0
       ENDIF

       IF (B.GE.0) THEN

C **********  STOPPED  **********

       IF ((A(ISPEED).EQ.0).AND.(A(IRPM).GT.0)) THEN

         Y = 0

       ENDIF

C ***********  ACCELS x 3  **********

C      **  HARD ACCEL  **

       IF (ACCL.GT.(0.3)) THEN
         IF (A(IOLF).EQ.1) THEN

           Y = 6

           Z = VB(A(ISPEED))

         ELSE

C      **  MEDIUM ACCEL  **

           ACLM = (A(ISPEED) * 0.0385) + 3.54
           IF (ACCL.GT.(ACLM)) THEN

            Y = 5

            Z = VB(A(ISPEED))

           ELSE

C      **  LIGHT ACCEL  **

            Y = 4

            Z = VB(A(ISPEED))

           ENDIF
         ENDIF
       ENDIF

C **********  DECELS AND CRUISE  **********

C      **  CRUISE  **

       IF ((A(ISPEED).GT.0).AND.((ACCL.LE.(0.300)).AND.
     >     (ACCL.GE.(-0.300)))) THEN
```

```
        IF  (A(ITP).GT.1)  THEN

          Y = 3

          Z  =  VB(A(ISPEED))

        ELSE

C     **  COAST  **

          Y = 2

          Z  =  VB(A(ISPEED))

        ENDIF
      ENDIF

C     **  LIGHT DECEL  **

      IF ((ACCL.LT.(-0.300)).AND.(A(ISPEED).GT.0)) THEN
        IF  (A(IBRAKE).EQ.0)  THEN

          Y = 7

          Z  =  VB(A(ISPEED))

C     **  LOW VEL MEDIUM DECEL  **

        ELSE
          IF  (A(ISPEED).LT.20)  THEN
            IF  (ACCL.GT.(-0.4  *  (A(ISPEED))))  THEN

            Y = 8

            Z  =  VB(A(ISPEED))

C     **  LOW VEL HARD DECEL  **

            ELSE

            Y = 9

            Z  =  VB(A(ISPEED))


            ENDIF

C     **  HIGH VEL MEDIUM DECEL  **

          ELSE
            IF  (ACCL.GT.(-8))  THEN

            Y = 8

            Z  =  VB(A(ISPEED))

C     **  HIGH VEL HARD DECEL  **

            ELSE

            Y = 9
```

```
            Z = VB(A(ISPEED))

          ENDIF
        ENDIF
      ENDIF
    ENDIF

    ENDIF

C  *  READ EMISSIONS DATA INTO BINS  *

    HN(Y,Z) = HN(Y,Z) + 1
    HS(Y,Z) = HS(Y,Z) + HCMASS
    HQ(Y,Z) = HQ(Y,Z) + (HCMASS*HCMASS)
    CN(Y,Z) = CN(Y,Z) + 1
    CS(Y,Z) = CS(Y,Z) + COMASS
    CQ(Y,Z) = CQ(Y,Z) + (COMASS*COMASS)
    NN(Y,Z) = NN(Y,Z) + 1
    NS(Y,Z) = NS(Y,Z) + NOMASS
    NQ(Y,Z) = NQ(Y,Z) + (NOMASS*NOMASS)


C  *  SET OLD SPEED FOR ACCELERATION CALCULATION  *

    OLDSPD = A(ISPEED)


C ************************************************************
C  *****  END OPEN LOOP AND MODAL ANALYSIS  *****
C ************************************************************

100   CONTINUE
120   CONTINUE


C ************************************************************
C ***************  STATISTICAL CALCULATIONS  *****************
C ************************************************************

      DO 160 M = 0, 9, 1
       DO 140 V = 0, 7, 1

      IF (HN(M,V).EQ.0) THEN
        HA(M,V) = -9.9999
        HS(M,V) = -9.9999
C          HD(M,V) = -9.9999
      ELSEIF (HN(M,V).LT.2) THEN
        HA(M,V)=HS(M,V)/HN(M,V)
C          HD(M,V) = -9.9999
      ELSE
        HA(M,V)=HS(M,V)/HN(M,V)
C          HD(M,V)=SQRT((HQ(M,V)-(HS(M,V)*HS(M,V))/HN(M,V))
C     >       /(HN(M,V)-1))
      ENDIF

      IF (CN(M,V).EQ.0) THEN
        CA(M,V) = -9.9999
        CS(M,V) = -9.9999
C          CD(M,V) = -9.9999
      ELSEIF (CN(M,V).LT.2) THEN
```

```
          CA(M,V)=CS(M,V)/CN(M,V)
C            CD(M,V) = -9.9999
        ELSE
          CA(M,V)=CS(M,V)/CN(M,V)
C            CD(M,V)=SQRT((CQ(M,V)-(CS(M,V)*CS(M,V))/CN(M,V))
C       >       /(CN(M,V)-1))
        ENDIF

        IF (NN(M,V).EQ.0) THEN
          NA(M,V) = -9.9999
          NS(M,V) = -9.9999
C            ND(M,V) = -9.9999
        ELSEIF (NN(M,V).LT.2) THEN
          NA(M,V)=NS(M,V)/NN(M,V)
C            ND(M,V) = -9.9999
        ELSE
          NA(M,V)=NS(M,V)/NN(M,V)
C            ND(M,V)=SQRT((NQ(M,V)-(NS(M,V)*NS(M,V))/NN(M,V))
C       >       /(NN(M,V)-1))
        ENDIF

140     CONTINUE
160     CONTINUE


C *****************************************************************
C ****************  WRITE RESULTS TO OUTFILE  ****************
C *****************************************************************

        WRITE (4,*) ' '
        WRITE (4,*) '  '
        WRITE (4,*) 'MASS EMISSIONS BY VEL AND ACCEL CALCULATIONS'
        WRITE (4,*) '  '
        WRITE (4,200) VDASIN
200       FORMAT ('       VDAS data file:        ', A12)
        WRITE (4,220) EMISIN
220       FORMAT ('       Emissions data file: ', A12)
        WRITE (4,*) '________________________________________',
      >             '__________________________________'
        WRITE (4,*) ' '
        WRITE (4,*) ' '
        WRITE (4,*) ' '
        WRITE (4,*) 'HC Mass Emissions by Mode (g/sec):  '
        WRITE (4,*) '  '
        WRITE (4,*) 'Mode              0-10    10-20    20-30    30-40',
      >             '     40-50    50-60    60-70    70+'
        WRITE (4,*) '----------------------------------------',
      >             '----------------------------------'
        WRITE (4,400) 'Stopped     : ', HA(0,0)
        WRITE (4,400) 'Start       : ', HA(1,0),HA(1,1),HA(1,2),
      >  HA(1,3),HA(1,4),HA(1,5),HA(1,6),HA(1,7)
        WRITE (4,400) 'Coast       : ', HA(2,0),HA(2,1),HA(2,2),
      >  HA(2,3),HA(2,4),HA(2,5),HA(2,6),HA(2,7)
        WRITE (4,400) 'Cruise      : ', HA(3,0),HA(3,1),HA(3,2),
      >  HA(3,3),HA(3,4),HA(3,5),HA(3,6),HA(3,7)
        WRITE (4,400) 'Light Accel: ', HA(4,0),HA(4,1),HA(4,2),
      >  HA(4,3),HA(4,4),HA(4,5),HA(4,6),HA(4,7)
        WRITE (4,400) 'Med Accel   : ', HA(5,0),HA(5,1),HA(5,2),
      >  HA(5,3),HA(5,4),HA(5,5),HA(5,6),HA(5,7)
        WRITE (4,400) 'Hard Accel : ', HA(6,0),HA(6,1),HA(6,2),
      >  HA(6,3),HA(6,4),HA(6,5),HA(6,6),HA(6,7)
```

```
 WRITE (4,400) 'Light Decel: ', HA(7,0),HA(7,1),HA(7,2),
>  HA(7,3),HA(7,4),HA(7,5),HA(7,6),HA(7,7)
 WRITE (4,400) 'Med Decel   : ', HA(8,0),HA(8,1),HA(8,2),
>  HA(8,3),HA(8,4),HA(8,5),HA(8,6),HA(8,7)
 WRITE (4,400) 'Hard Decel : ', HA(9,0),HA(9,1),HA(9,2),
>  HA(9,3),HA(9,4),HA(9,5),HA(9,6),HA(9,7)
 WRITE (4,*) ' '
 WRITE (4,*) ' '
 WRITE (4,*) ' '
 WRITE (4,*) ' '
 WRITE (4,*) 'CO Mass Emissions by Mode (g/sec):  '
 WRITE (4,*) '  '
 WRITE (4,*) 'Mode              0-10   10-20   20-30   30-40',
>            '   40-50   50-60   60-70    70+'
 WRITE (4,*) '-----------------------------------------',
>            '---------------------------------'
 WRITE (4,400) 'Stopped     : ', CA(0,0)
 WRITE (4,400) 'Start       : ', CA(1,0),CA(1,1),CA(1,2),
>  CA(1,3),CA(1,4),CA(1,5),CA(1,6),CA(1,7)
 WRITE (4,400) 'Coast       : ', CA(2,0),CA(2,1),CA(2,2),
>  CA(2,3),CA(2,4),CA(2,5),CA(2,6),CA(2,7)
 WRITE (4,400) 'Cruise      : ', CA(3,0),CA(3,1),CA(3,2),
>  CA(3,3),CA(3,4),CA(3,5),CA(3,6),CA(3,7)
 WRITE (4,400) 'Light Accel: ', CA(4,0),CA(4,1),CA(4,2),
>  CA(4,3),CA(4,4),CA(4,5),CA(4,6),CA(4,7)
 WRITE (4,400) 'Med Accel   : ', CA(5,0),CA(5,1),CA(5,2),
>  CA(5,3),CA(5,4),CA(5,5),CA(5,6),CA(5,7)
 WRITE (4,400) 'Hard Accel : ', CA(6,0),CA(6,1),CA(6,2),
>  CA(6,3),CA(6,4),CA(6,5),CA(6,6),CA(6,7)
 WRITE (4,400) 'Light Decel: ', CA(7,0),CA(7,1),CA(7,2),
>  CA(7,3),CA(7,4),CA(7,5),CA(7,6),CA(7,7)
 WRITE (4,400) 'Med Decel   : ', CA(8,0),CA(8,1),CA(8,2),
>  CA(8,3),CA(8,4),CA(8,5),CA(8,6),CA(8,7)
 WRITE (4,400) 'Hard Decel : ', CA(9,0),CA(9,1),CA(9,2),
>  CA(9,3),CA(9,4),CA(9,5),CA(9,6),CA(9,7)
 WRITE (4,*) ' '
 WRITE (4,*) ' '
 WRITE (4,*) ' '
 WRITE (4,*) ' '
 WRITE (4,*) 'NOx Mass Emissions by Mode (g/sec):  '
 WRITE (4,*) '  '
 WRITE (4,*) 'Mode              0-10   10-20   20-30   30-40',
>            '   40-50   50-60   60-70    70+'
 WRITE (4,*) '-----------------------------------------',
>            '---------------------------------'
 WRITE (4,400) 'Stopped     : ', NA(0,0)
 WRITE (4,400) 'Start       : ', NA(1,0),NA(1,1),NA(1,2),
>  NA(1,3),NA(1,4),NA(1,5),NA(1,6),NA(1,7)
 WRITE (4,400) 'Coast       : ', NA(2,0),NA(2,1),NA(2,2),
>  NA(2,3),NA(2,4),NA(2,5),NA(2,6),NA(2,7)
 WRITE (4,400) 'Cruise      : ', NA(3,0),NA(3,1),NA(3,2),
>  NA(3,3),NA(3,4),NA(3,5),NA(3,6),NA(3,7)
 WRITE (4,400) 'Light Accel: ', NA(4,0),NA(4,1),NA(4,2),
>  NA(4,3),NA(4,4),NA(4,5),NA(4,6),NA(4,7)
 WRITE (4,400) 'Med Accel   : ', NA(5,0),NA(5,1),NA(5,2),
>  NA(5,3),NA(5,4),NA(5,5),NA(5,6),NA(5,7)
 WRITE (4,400) 'Hard Accel : ', NA(6,0),NA(6,1),NA(6,2),
>  NA(6,3),NA(6,4),NA(6,5),NA(6,6),NA(6,7)
 WRITE (4,400) 'Light Decel: ', NA(7,0),NA(7,1),NA(7,2),
>  NA(7,3),NA(7,4),NA(7,5),NA(7,6),NA(7,7)
 WRITE (4,400) 'Med Decel   : ', NA(8,0),NA(8,1),NA(8,2),
```

```
     >  NA(8,3),NA(8,4),NA(8,5),NA(8,6),NA(8,7)
      WRITE (4,400) 'Hard Decel : ', NA(9,0),NA(9,1),NA(9,2),
     >  NA(9,3),NA(9,4),NA(9,5),NA(9,6),NA(9,7)

400   FORMAT (' ', A12, 8F8.4)

C *************************************************************
C *****  WRITE RAW MODE OCCURENCES TO OUTPUT SAVE FILE  *****
C *************************************************************

      DO 410 M = 0, 9, 1
       DO 405 V = 0, 7, 1

      WRITE (2,500) HN(M,V), HS(M,V), HD(M,V)

405   CONTINUE
410   CONTINUE

      DO 430 M = 0, 9, 1
       DO 420 V = 0, 7, 1

      WRITE (2,500) CN(M,V), CS(M,V), CD(M,V)

420   CONTINUE
430   CONTINUE

      DO 450 M = 0, 9, 1
       DO 440 V = 0, 7, 1

      WRITE (2,500) NN(M,V), NS(M,V), ND(M,V)

440   CONTINUE
450   CONTINUE

500   FORMAT (' ',3F15.6)

      END

C **********************************************************************
C       ****************  END MAIN PROGRAM  **********************
C **********************************************************************

C **********************************************************************
C       ******************   FUNCTIONS  ************************
C **********************************************************************

C  *****  FUNCTION GETLAB  *****

c  by G. Jesion, Ford Motor Company
c  Copyrite, 1991

      integer function getlab(lab,list)
      character *(*) lab,list
      character*20 test

      index=1
      do i=1,40
        test='                    '
        do j=1,40
          if(list(index:index).EQ.' ') then
            do k=1,40
```

```
          if(list(index:index).NE.' ') go to 10
          index=index+1
          enddo
        endif
        test(j:j)=list(index:index)
        index=index+1
      enddo
 10     continue
      if(test.EQ.lab) then
        getlab=i
        return
      endif
    enddo
    print *,lab,' not found!'
    stop
    return
    end

C  *****  FUNCTION GETNUM  *****

    integer function getnum(t)
    character*(*) t
    index=1
    iword=0
    isspace=1
    do i=1,400
      if(t(index:index).NE.' ') then
        isspace=0
      else
        if(isspace.EQ.0) then
          iword=iword+1
          isspace=1
        endif
      endif
      index=index+1
    enddo
    getnum=iword
    return
    end

C  *****  FUNCTION VELBIN  *****

    INTEGER FUNCTION VB(V)

    REAL V

    IF ((V.GE.0).AND.(V.LT.10))  VB = 0
    IF ((V.GE.10).AND.(V.LT.20)) VB = 1
    IF ((V.GE.20).AND.(V.LT.30)) VB = 2
    IF ((V.GE.30).AND.(V.LT.40)) VB = 3
    IF ((V.GE.40).AND.(V.LT.50)) VB = 4
    IF ((V.GE.50).AND.(V.LT.60)) VB = 5
    IF ((V.GE.60).AND.(V.LT.70)) VB = 6
    IF (V.GE.70)                 VB = 7

    RETURN
    END

C ***********************************************************************
C      ***********************  END PROGRAM  ***********************
C ***********************************************************************
```

A.2.2 Acceleration and Speed-based Emissions Averaging Program AVGM.FOR

```
C ********************************************************************
C
C     PROGRAM AVEM (AVERAGE EMISSIONS FROM ACCEL AND VEL ESTIMATION
C                   PROGRAM)
C     MARCH 22, 1993    VER. 1.0
C
C ********************************************************************
C
C     THIS PROGRAM WRITTEN BY:
C         MICHAEL J. ST. DENIS
C         ATMOSPHERIC INNOVATIVE RESEARCH
C         5025 DENNY AVENUE, #6
C         NORTH HOLLYWOOD, CA 91601
C         (818) 761-6048
C
C     WRITTEN FOR AND PROPERTY OF:
C         THE SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
C         21865 EAST COPELY DRIVE
C         DIAMOND BAR, CA 91765
C
C ********************************************************************
C
C     THIS PROGRAM READS IN A VARIABLE NUMBER OF BINNED ACCEL AND VEL
C     BASED EMISSIONS FILES, AND AVERAGES THE EMISSIONS IN EACH BIN.
C     THE OUTPUT FILE CONTAINS THE AVERAGED EMISSIONS FOR EACH BIN
C     FOR USE IN ESTIMATING ON-ROAD EMISSIONS.
C
C ********************************************************************
C
C     VARIABLE DECLARATION SECTION:
C
C
C     VARIABLE ARRAYS ARE DEFINED AS FOLLOWS...
C
C         RT(X,Y)  WHERE...
C
C         R = EMISSIONS COMPOUND
C           H - HYDROCARBON
C           C - CARBON MONOXIDE
C           N - OXIDES OF NITROGEN
C
C         T = VARIABLE TYPE
C           N - SAMPLE NUMBER
C           S - SUM
C           A - AVERAGE
C
C         X = LOAD BASED MODE
C           0 - COLD START    ( COOLANT TEMP < 160 )
C           1 - HOT START     ( COOLANT TEMP >= 160 )
C           2 - OPEN LOOP RICH
C           3 - OPEN LOOP LEAN
C           4 - HIGH LOAD     ( 0.65 < LOAD)
C           5 - MEDIUM LOAD   ( 0.40 < LOAD <= 0.65 )
C           6 - LOW LOAD      ( LOAD <= 0.40 )
C
C         Y = VELOCITY RANGE
C           0 - 0  TO 10 MPH
```

```
C           1 - 10 TO 20 MPH
C           2 - 20 TO 30 MPH
C           3 - 30 TO 40 MPH
C           4 - 40 TO 50 MPH
C           5 - 50 TO 60 MPH
C           6 - 60 TO 70 MPH
C           7 - 70 MPH PLUS
C
C     OTHER VARIABLES
C
C      MASS - MASS POLLUTANT READ IN
C      NUM  - NUMBER OF EMISSIONS MEASUREMENTS IN EACH BIN
C      VDASIN - FILE WITH VDAS DATA
C      EMISIN - FILE WITH BINNED EMISSIONS DATA
C      EMISVW - FILE TO WRITE FOR VIEWING
C      EMISOT - FILE TO WRITE FOR INUPT TO EMISSIONS MODEL
C
C ******************************************************************

C *************  VARIABLE DECLARATION SECTION  ****************

      REAL  HS(0:9,0:7), CS(0:9,0:7), NS(0:9,0:7)
      REAL  HN(0:9,0:7), CN(0:9,0:7), NN(0:9,0:7)
      REAL  HA(0:9,0:7), CA(0:9,0:7), NA(0:9,0:7)

      REAL  NUM, MASS

      INTEGER  M, V

      CHARACTER*40   EMISFL, EMISVW, EMISOT, EMISIN

C ********************************************************
C       **********   BEGIN MAIN PROGRAM  ***********
C ********************************************************

C ************  READ IN FILE NAMES FOR I/O  ************


      READ (*,'(A)') EMISFL
      READ (*,'(A)') EMISVW
      READ (*,'(A)') EMISOT
      OPEN (7, FILE = EMISFL)
      OPEN (4, FILE = EMISVW)
      OPEN (5, FILE = EMISOT)


C **********  PRESET VARIABLES  ***************


      DO 2 M = 0, 9, 1
       DO 1 V = 0, 7, 1

      HN(M,V)  = 0
      CN(M,V)  = 0
      NN(M,V)  = 0

      HS(M,V)  = 0
      CS(M,V)  = 0
      NS(M,V)  = 0

1     CONTINUE
```

```
 2     CONTINUE

C ***************  BEGIN MAIN CALCULATIONS  ****************

C ****************  READ IN THE MASS OF EMISSIONS  *****************

      DO 900 I = 0, 1000000, 1
      READ (7,'(A)',END=950) EMISIN
      OPEN (3, FILE = EMISIN)

      DO 20 M = 0, 9, 1
       DO 10 V = 0, 7, 1

       READ (3,80,END=30) NUM, MASS
       IF (NUM.GE.0.5) THEN
       HN(M,V) = NUM  + HN(M,V)
       HS(M,V) = MASS + HS(M,V)
       ENDIF

10     CONTINUE
20    CONTINUE
30    CONTINUE

      DO 21 M = 0, 9, 1
       DO 11 V = 0, 7, 1

       READ (3,80,END=31) NUM, MASS
       IF (NUM.GE.0.5) THEN
       CN(M,V) = NUM  + CN(M,V)
       CS(M,V) = MASS + CS(M,V)
       ENDIF

11     CONTINUE
21    CONTINUE
31    CONTINUE

      DO 22 M = 0, 9, 1
       DO 12 V = 0, 7, 1

       READ (3,80,END=32) NUM, MASS
       IF (NUM.GE.0.5) THEN
       NN(M,V) = NUM  + NN(M,V)
       NS(M,V) = MASS + NS(M,V)
       ENDIF

12     CONTINUE
22    CONTINUE
32    CONTINUE

80     FORMAT (2F15.6)

       CLOSE (3)

900   CONTINUE
950   CONTINUE

C ***************  STATISTICAL CALCULATIONS  ****************

      DO 160 M = 0, 9, 1
       DO 140 V = 0, 7, 1
```

```
      IF (HN(M,V).LT.0.5) THEN
        HA(M,V) = -9.999
      ELSE
        HA(M,V) = HS(M,V) / HN(M,V)
      ENDIF

      IF (CN(M,V).LT.0.5) THEN
        CA(M,V) = -9.999
      ELSE
        CA(M,V) = CS(M,V) / CN(M,V)
      ENDIF

      IF (NN(M,V).LT.0.5) THEN
        NA(M,V) = -9.999
      ELSE
        NA(M,V) = NS(M,V) / NN(M,V)
      ENDIF

140     CONTINUE
160   CONTINUE

C ************  WRITE RESULTS TO VIEW FILE  ************

      WRITE (4,*) ' '
      WRITE (4,*) '  '
      WRITE (4,*) 'AVG MASS EMISSIONS BY VEL AND ACCEL CALCULATIONS'
      WRITE (4,*) '  '
      WRITE (4,200) EMISFL
200     FORMAT ('      Emissions data files list:      ', A12)
      WRITE (4,220) EMISOT
220     FORMAT ('      Emissions output data file:     ', A12)
      WRITE (4,*) '________________________________________',
     >            '_________________________________'
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) 'HC Mass Emissions by Mode (g/sec):  '
      WRITE (4,*) '  '
      WRITE (4,*) 'Mode              0-10   10-20   20-30   30-40',
     >            '   40-50   50-60   60-70    70+'
      WRITE (4,*) '----------------------------------------',
     >            '---------------------------------'
      WRITE (4,400) 'Stopped     : ', HA(0,0)
      WRITE (4,400) 'Start       : ', HA(1,0),HA(1,1),HA(1,2),
     >  HA(1,3),HA(1,4),HA(1,5),HA(1,6),HA(1,7)
      WRITE (4,400) 'Coast       : ', HA(2,0),HA(2,1),HA(2,2),
     >  HA(2,3),HA(2,4),HA(2,5),HA(2,6),HA(2,7)
      WRITE (4,400) 'Cruise      : ', HA(3,0),HA(3,1),HA(3,2),
     >  HA(3,3),HA(3,4),HA(3,5),HA(3,6),HA(3,7)
      WRITE (4,400) 'Light Accel: ', HA(4,0),HA(4,1),HA(4,2),
     >  HA(4,3),HA(4,4),HA(4,5),HA(4,6),HA(4,7)
      WRITE (4,400) 'Med Accel  : ', HA(5,0),HA(5,1),HA(5,2),
     >  HA(5,3),HA(5,4),HA(5,5),HA(5,6),HA(5,7)
      WRITE (4,400) 'Hard Accel : ', HA(6,0),HA(6,1),HA(6,2),
     >  HA(6,3),HA(6,4),HA(6,5),HA(6,6),HA(6,7)
      WRITE (4,400) 'Light Decel: ', HA(7,0),HA(7,1),HA(7,2),
     >  HA(7,3),HA(7,4),HA(7,5),HA(7,6),HA(7,7)
      WRITE (4,400) 'Med Decel  : ', HA(8,0),HA(8,1),HA(8,2),
     >  HA(8,3),HA(8,4),HA(8,5),HA(8,6),HA(8,7)
      WRITE (4,400) 'Hard Decel : ', HA(9,0),HA(9,1),HA(9,2),
     >  HA(9,3),HA(9,4),HA(9,5),HA(9,6),HA(9,7)
```

```
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) 'CO Mass Emissions by Mode (g/sec):  '
      WRITE (4,*) '  '
      WRITE (4,*) 'Mode               0-10   10-20   20-30   30-40',
     >            '   40-50   50-60   60-70    70+'
      WRITE (4,*) '----------------------------------------',
     >            '--------------------------------'
      WRITE (4,400) 'Stopped    : ', CA(0,0)
      WRITE (4,400) 'Start      : ', CA(1,0),CA(1,1),CA(1,2),
     >  CA(1,3),CA(1,4),CA(1,5),CA(1,6),CA(1,7)
      WRITE (4,400) 'Coast      : ', CA(2,0),CA(2,1),CA(2,2),
     >  CA(2,3),CA(2,4),CA(2,5),CA(2,6),CA(2,7)
      WRITE (4,400) 'Cruise     : ', CA(3,0),CA(3,1),CA(3,2),
     >  CA(3,3),CA(3,4),CA(3,5),CA(3,6),CA(3,7)
      WRITE (4,400) 'Light Accel: ', CA(4,0),CA(4,1),CA(4,2),
     >  CA(4,3),CA(4,4),CA(4,5),CA(4,6),CA(4,7)
      WRITE (4,400) 'Med Accel  : ', CA(5,0),CA(5,1),CA(5,2),
     >  CA(5,3),CA(5,4),CA(5,5),CA(5,6),CA(5,7)
      WRITE (4,400) 'Hard Accel : ', CA(6,0),CA(6,1),CA(6,2),
     >  CA(6,3),CA(6,4),CA(6,5),CA(6,6),CA(6,7)
      WRITE (4,400) 'Light Decel: ', CA(7,0),CA(7,1),CA(7,2),
     >  CA(7,3),CA(7,4),CA(7,5),CA(7,6),CA(7,7)
      WRITE (4,400) 'Med Decel  : ', CA(8,0),CA(8,1),CA(8,2),
     >  CA(8,3),CA(8,4),CA(8,5),CA(8,6),CA(8,7)
      WRITE (4,400) 'Hard Decel : ', CA(9,0),CA(9,1),CA(9,2),
     >  CA(9,3),CA(9,4),CA(9,5),CA(9,6),CA(9,7)
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) 'NOx Mass Emissions by Mode (g/sec):  '
      WRITE (4,*) '  '
      WRITE (4,*) 'Mode               0-10   10-20   20-30   30-40',
     >            '   40-50   50-60   60-70    70+'
      WRITE (4,*) '----------------------------------------',
     >            '--------------------------------'
      WRITE (4,400) 'Stopped    : ', NA(0,0)
      WRITE (4,400) 'Start      : ', NA(1,0),NA(1,1),NA(1,2),
     >  NA(1,3),NA(1,4),NA(1,5),NA(1,6),NA(1,7)
      WRITE (4,400) 'Coast      : ', NA(2,0),NA(2,1),NA(2,2),
     >  NA(2,3),NA(2,4),NA(2,5),NA(2,6),NA(2,7)
      WRITE (4,400) 'Cruise     : ', NA(3,0),NA(3,1),NA(3,2),
     >  NA(3,3),NA(3,4),NA(3,5),NA(3,6),NA(3,7)
      WRITE (4,400) 'Light Accel: ', NA(4,0),NA(4,1),NA(4,2),
     >  NA(4,3),NA(4,4),NA(4,5),NA(4,6),NA(4,7)
      WRITE (4,400) 'Med Accel  : ', NA(5,0),NA(5,1),NA(5,2),
     >  NA(5,3),NA(5,4),NA(5,5),NA(5,6),NA(5,7)
      WRITE (4,400) 'Hard Accel : ', NA(6,0),NA(6,1),NA(6,2),
     >  NA(6,3),NA(6,4),NA(6,5),NA(6,6),NA(6,7)
      WRITE (4,400) 'Light Decel: ', NA(7,0),NA(7,1),NA(7,2),
     >  NA(7,3),NA(7,4),NA(7,5),NA(7,6),NA(7,7)
      WRITE (4,400) 'Med Decel  : ', NA(8,0),NA(8,1),NA(8,2),
     >  NA(8,3),NA(8,4),NA(8,5),NA(8,6),NA(8,7)
      WRITE (4,400) 'Hard Decel : ', NA(9,0),NA(9,1),NA(9,2),
     >  NA(9,3),NA(9,4),NA(9,5),NA(9,6),NA(9,7)

 400  FORMAT (' ', A12, 8F8.4)
```

```
C ************  WRITE RESULTS TO OUTFILE  ************

      DO 410 M = 0, 9, 1
       DO 405 V = 0, 7, 1

      WRITE (5,500) HA(M,V)

405   CONTINUE
410   CONTINUE

      DO 430 M = 0, 9, 1
       DO 420 V = 0, 7, 1

      WRITE (5,500) CA(M,V)

420   CONTINUE
430   CONTINUE

      DO 450 M = 0, 9, 1
       DO 440 V = 0, 7, 1

      WRITE (5,500) NA(M,V)

440   CONTINUE
450   CONTINUE

500   FORMAT (' ',F15.6)

      END

C *******************************************************************
C      ***************  END MAIN PROGRAM  *********************
C ********************************************************************
```

A.2.3 Acceleration and Speed-based Emissions Estimating Program MODEIO.FOR

```
C **********************************************************************
C
C      PROGRAM MODEIO (EMISSIONS ESTIMATING PROGRAM BASED ON
C                      VEL AND ACCL MODES)
C      MARCH 22, 1993    VER. 1.0
C
C **********************************************************************
C
C      THIS PROGRAM WRITTEN BY:
C          MICHAEL J. ST. DENIS
C          ATMOSPHERIC INNOVATIVE RESEARCH
C          5025 DENNY AVENUE, #6
C          NORTH HOLLYWOOD, CA 91601
C          (818) 761-6048
C
C      WRITTEN FOR AND PROPERTY OF:
C          THE SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
C          21865 EAST COPELY DRIVE
C          DIAMOND BAR, CA 91765
C
C **********************************************************************
C
C     THIS PROGRAM READS IN AN ON-ROAD VDAS .DRW DATA FILE WHICH HAS BEEN
C     CONVERTED TO AN .AEU DATA FILE (ASCII) BY THE PROGRAM
C     V5CVT.EXE, AND CALCULATES THE FREQUENCY OF THE MODE THE VEHICLE
C     IS IN AND USES AN AVERAGE EMISSIONS FILE TO CALCULATE THE ON-ROAD
C     EMISSIONS OF HC, CO, AND NOX AS A FUNCTION OF TIME AND OF
C     DISTANCE TRAVELED.
C
C **********************************************************************
C
C     VARIABLE DECLARATION SECTION:
C
C
C     VARIABLE ARRAYS ARE DEFINED AS FOLLOWS...
C
C         RT(X,Y)  WHERE...
C
C         R = EMISSIONS COMPOUND
C           H - HYDROCARBON
C           C - CARBON MONOXIDE
C           N - OXIDES OF NITROGEN
C
C         T = VARIABLE TYPE
C           A - AVERAGE
C
C         X = VEL AND ACCL BASED MODES
C           0 - STOPPED
C           1 - START
C           2 - COAST
C           3 - CRUISE
C           4 - LIGHT ACCEL
C           5 - MEDIUM ACCEL
C           6 - HARD ACCEL
C           7 - LIGHT DECEL
C           8 - MEDIUM DECEL
C           9 - HARD DECEL
```

```
C
C          Y = VELOCITY RANGE
C            0 - 0  TO 10 MPH
C            1 - 10 TO 20 MPH
C            2 - 20 TO 30 MPH
C            3 - 30 TO 40 MPH
C            4 - 40 TO 50 MPH
C            5 - 50 TO 60 MPH
C            6 - 60 TO 70 MPH
C            7 - 70 MPH PLUS
C
C      OTHER VARIABLES
C
C       ACLM   - ACCELERATION MODE
C       BININ  - FILE WITH BINNED, AVERAGED EMISSIONS DATA
C       CF     - SUM MASS OF CARBON MONOXIDE IN EMISSIONS FILE
C       CMERD  - CARBON MONOXIDE MASS EMISSIONS RATE, DISTANCE
C       CMERT  - CARBON MONOXIDE MASS EMISSIONS RATE, TIME
C       DIST   - DISTANCE TRAVELED
C       EMISOT - FILE TO WRITE FOR VIEWING
C       HF     - SUM MASS OF HYDROCARBON IN EMISSIONS FILE
C       HMERD  - HYDROCARBON MASS EMISSIONS RATE, DISTANCE
C       HMERT  - HYDROCARBON MASS EMISSIONS RATE, TIME
C       MASS   - MASS POLLUTANT READ IN
C       NF     - SUM MASS OF OXIDE OF NITROGEN IN EMISSIONS FILE
C       NMERD  - OXIDES OF NITROGEN MASS EMISSIONS RATE, DISTANCE
C       NMERT  - OXIDES OF NITROGEN MASS EMISSIONS RATE, TIME
C       NUM(XXX,YYY) - NUMBER OF OCCURRENCES ON MODE (XXX,YYY) ON-ROAD
C       START  - IS COLD START PRESENT
C       TIME   - TOTAL TIME ON-ROAD
C       VB     - FUNCTION TO DETERMINE VELOCITY BIN
C       OP     - FLAG AS TO WRITE OUTPUT FILE
C       VDASIN - FILE WITH VDAS DATA
C
C *******************************************************************


C *************  VARIABLE DECLARATION SECTION  ****************

      REAL  HA(0:9,0:7), CA(0:9,0:7), NA(0:9,0:7), NUM(0:9,0:7)

      REAL  MASS, DIST, HF, CF, NF
      REAL  HMERT, CMERT, NMERT, HMERD, CMERD, NMERD

      REAL  ACLM
      real  a(400)

      INTEGER  B, Z, START, I, VB, TIME, M, V, Y
      INTEGER  getnum, getlab, OP

      CHARACTER*40   VDASIN, BININ, EMISOT
      character*400  header

C *******************************************************************
C       ******************   BEGIN MAIN PROGRAM  ****************
C *******************************************************************

C ************  READ IN FILE NAMES FOR I/O  ************


      READ (*,'(A)') VDASIN
```

```
      READ (*,'(A)') BININ
      READ (*,'(A)') EMISOT
      OPEN (3, FILE = VDASIN)
      OPEN (7, FILE = BININ)
      OPEN (4, FILE = EMISOT)

C **********  PRESET VARIABLES  ***************

      START = 0
      DIST = 0
      HF = 0
      CF = 0
      NF = 0
      OP = 1

      DO 2 M = 0, 9, 1
       DO 1 V = 0, 7, 1

      NUM(M,V) = 0

1     CONTINUE
2     CONTINUE

C ***************  BEGIN MAIN CALCULATIONS  ****************

C ******************  READ IN THE VDAS DATA AND  *******************

      READ (3,'(a)')header

c get # of channels
      ilen=getnum(header)

c get indices of variables needed
      irpm=getlab('n',header)
      ispeed=getlab('vs',header)
      ibrake=getlab('boo_lvl',header)
      iolf=getlab('olflg',header)
      itp=getlab('tp_rel',header)

      DO 100 I = 1, 1000000, 1

C ****************  READ IN THE MASS OF EMISSIONS  *****************

      READ (3,*,END=120) (a(k),k=1,ilen)

C *************  VEL AND ACCL  BASED MODAL ANALYSIS  **************

      DIST = DIST + (A(ISPEED) / 3600)

      IF (I.EQ.1) OLDSPD = A(ISPEED)

      ACCL = A(ISPEED) - OLDSPD

C **********  START  **********

      IF (((I.EQ.1).AND.(A(IOLF).EQ.1)).OR.((B.EQ.-1).AND.
     >   (A(IOLF).EQ.1))) THEN

        Y = 1
        Z = VB(A(ISPEED))
```

```
        NUM(Y,Z) = NUM(Y,Z) + 1

        B = -1
      ELSE
        B = 0
      ENDIF

      IF (B.GE.0) THEN

C **********  STOPPED  **********

      IF ((A(ISPEED).EQ.0).AND.(A(IRPM).GT.0)) THEN

        Y = 0
        Z = VB(A(ISPEED))
        NUM(Y,Z) = NUM(Y,Z) + 1

      ENDIF

C ***********  ACCELS x 3  **********

C     **  HARD ACCEL  **

      IF (ACCL.GT.(0.3)) THEN
        IF (A(IOLF).EQ.1) THEN

          Y = 6
          Z = VB(A(ISPEED))
          NUM(Y,Z) = NUM(Y,Z) + 1

        ELSE

C     **  MEDIUM ACCEL  **

          ACLM = (A(ISPEED) * 0.0385) + 3.54
          IF (ACCL.GT.(ACLM)) THEN

            Y = 5
            Z = VB(A(ISPEED))
            NUM(Y,Z) = NUM(Y,Z) + 1

          ELSE

C     **  LIGHT ACCEL  **

            Y = 4
            Z = VB(A(ISPEED))
            NUM(Y,Z) = NUM(Y,Z) + 1

          ENDIF
        ENDIF
      ENDIF

C **********  DECELS AND CRUISE  **********

C     **  CRUISE  **

      IF ((A(ISPEED).GT.0).AND.((ACCL.LE.(0.300)).AND.
     >     (ACCL.GE.(-0.300)))) THEN
        IF (A(ITP).GT.1) THEN
```

```
            Y = 3
            Z = VB(A(ISPEED))
            NUM(Y,Z) = NUM(Y,Z) + 1

          ELSE

C     **  COAST  **

            Y = 2
            Z = VB(A(ISPEED))
            NUM(Y,Z) = NUM(Y,Z) + 1

          ENDIF
        ENDIF

C     **  LIGHT DECEL  **

        IF ((ACCL.LT.(-0.300)).AND.(A(ISPEED).GT.0)) THEN
          IF (A(IBRAKE).EQ.0) THEN

            Y = 7
            Z = VB(A(ISPEED))
            NUM(Y,Z) = NUM(Y,Z) + 1

C     **  LOW VEL MEDIUM DECEL  **

          ELSE
            IF (A(ISPEED).LT.20) THEN
              IF (ACCL.GT.(-0.4 * (A(ISPEED)))) THEN

              Y = 8
              Z = VB(A(ISPEED))
              NUM(Y,Z) = NUM(Y,Z) + 1

C     **  LOW VEL HARD DECEL  **

              ELSE

              Y = 9
              Z = VB(A(ISPEED))
              NUM(Y,Z) = NUM(Y,Z) + 1

              ENDIF

C     **  HIGH VEL MEDIUM DECEL  **

            ELSE
              IF (ACCL.GT.(-8)) THEN

              Y = 8
              Z = VB(A(ISPEED))
              NUM(Y,Z) = NUM(Y,Z) + 1

C     **  HIGH VEL HARD DECEL  **

              ELSE

              Y = 9
              Z = VB(A(ISPEED))
              NUM(Y,Z) = NUM(Y,Z) + 1
```

```
            ENDIF
          ENDIF
        ENDIF
      ENDIF

      ENDIF

C  *  SET OLD SPEED FOR ACCELERATION CALCULATION  *

      OLDSPD = A(ISPEED)

100   CONTINUE
120   CONTINUE

C  *****  END OPEN LOOP AND MODAL ANALYSIS  *****

C ***************  READ IN BINNED EMISSIONS DATA  ****************

      DO 20 M = 0, 9, 1
       DO 10 V = 0, 7, 1

       READ (7,80,END=30) MASS
       HA(M,V) = MASS

10     CONTINUE
20    CONTINUE
30    CONTINUE

      DO 21 M = 0, 9, 1
       DO 11 V = 0, 7, 1

       READ (7,80,END=31) MASS
       CA(M,V) = MASS

11     CONTINUE
21    CONTINUE
31    CONTINUE

      DO 22 M = 0, 9, 1
       DO 12 V = 0, 7, 1

       READ (7,80,END=32) MASS
       NA(M,V) = MASS

12     CONTINUE
22    CONTINUE
32    CONTINUE

80     FORMAT (F15.6)

C ***************  STATISTICAL CALCULATIONS  ****************

      TIME = I-1

      DO 160 M = 0, 9, 1
       DO 140 V = 0, 7, 1

      IF ((NUM(M,V).GT.0).AND.(HA(M,V).LT.0)) THEN
       IF (OP.EQ.1) THEN
        WRITE (*,*) 'FATAL ERROR.'
        WRITE (*,*) ' '
```

```
          WRITE (*,*) 'Mode(s) in VDAS data file not found in ',
     >                'emissions data, see output file. '
          WRITE (*,*) ' '
          WRITE (4,*) ' '
          WRITE (4,*) 'Modes were found in VDAS data but no',
     >                ' emissions data were found.'
          WRITE (4,227) VDASIN
 227        FORMAT (' VDAS data file: ', A40)
          WRITE (4,*) ' '
          WRITE (4,*) 'The modes are (accel and vel mode, ',
     >                'velocity, % time):'
           WRITE (4,*) ' '
         ENDIF

         WRITE (4,67) M, V, ((100*NUM(M,V))/TIME)
 67        FORMAT (' ',I2,I2,' ',F10.6)

         OP = 0

       ENDIF

       HF = (HA(M,V) * NUM(M,V)) + HF
       CF = (CA(M,V) * NUM(M,V)) + CF
       NF = (NA(M,V) * NUM(M,V)) + NF

140    CONTINUE
160    CONTINUE

       HMERT = HF / TIME
       CMERT = CF / TIME
       NMERT = NF / TIME

       HMERD = HF / DIST
       CMERD = CF / DIST
       NMERD = NF / DIST


C ************  WRITE RESULTS TO VIEWING OUTFILE  ************

       IF (OP.EQ.1) THEN

        WRITE (4,*) ' '
        WRITE (4,*) '  '
        WRITE (4,*) 'MASS EMISSIONS BY ACCEL AND VEL CALCULATIONS'
        WRITE (4,*) ' '
        WRITE (4,*) '  '
        WRITE (4,200) VDASIN
200     FORMAT ('       VDAS data file:      ', A40)
        WRITE (4,220) BININ
220     FORMAT ('       Emissions data file: ', A40)
        WRITE (4,*) '____________________________________________',
     >              '____________________________________'
        WRITE (4,*) '  '
        WRITE (4,410) TIME
410     FORMAT (' Driving time = ', I4, ' seconds.')
        WRITE (4,*) ' '
        WRITE (4,420) DIST
420     FORMAT (' Driving distance = ', F7.2, ' miles.')
        WRITE (4,*) '  '
        WRITE (4,*) '  '
        WRITE (4,*) '  '
```

```
      WRITE (4,*) 'Calculated Emitted Mass and Emission Rates:  '
      WRITE (4,*) ' '
      WRITE (4,*) 'Component                       total grams ',
     >            '      grams/sec      grams/mile'
      WRITE (4,*) '--------------------------------------------',
     >            '------------------------------'
      WRITE (4,400) HF, HMERT, HMERD
      WRITE (4,*) ' '
      WRITE (4,401) CF, CMERT, CMERD
      WRITE (4,*) ' '
      WRITE (4,402) NF, NMERT, NMERD
      WRITE (4,*) ' '
      WRITE (4,*) ' '

400   FORMAT (' Hydrocarbons        : ', 3F16.4)
401   FORMAT (' Carbon Monoxide     : ', 3F16.4)
402   FORMAT (' Oxides of Nitrogen : ', 3F16.4)

      ENDIF

      END

C *******************************************************************
C      ****************  END MAIN PROGRAM  *********************
C *******************************************************************

C *******************************************************************
C      ******************   FUNCTIONS  ***********************
C *******************************************************************

C  *****  FUNCTION GETLAB  *****

c  by G. Jesion, Ford Motor Company
c  Copyrite, 1991

      integer function getlab(lab,list)
      character *(*) lab,list
      character*20 test

      index=1
      do i=1,40
        test='                    '
        do j=1,40
          if(list(index:index).EQ.' ') then
            do k=1,40
            if(list(index:index).NE.' ') go to 10
            index=index+1
            enddo
          endif
          test(j:j)=list(index:index)
          index=index+1
        enddo
10        continue
        if(test.EQ.lab) then
          getlab=i
          return
        endif
      enddo
      print *,lab,' not found!'
      stop
      return
```

```
      end

C  *****  FUNCTION GETNUM  *****

      integer function getnum(t)
      character*(*) t
      index=1
      iword=0
      isspace=1
      do i=1,400
        if(t(index:index).NE.' ') then
          isspace=0
        else
          if(isspace.EQ.0) then
            iword=iword+1
            isspace=1
          endif
        endif
        index=index+1
      enddo
      getnum=iword
      return
      end

C  *****  FUNCTION VELBIN  *****

      INTEGER FUNCTION VB(V)

      REAL V

      IF ((V.GE.0).AND.(V.LT.10))  VB = 0
      IF ((V.GE.10).AND.(V.LT.20)) VB = 1
      IF ((V.GE.20).AND.(V.LT.30)) VB = 2
      IF ((V.GE.30).AND.(V.LT.40)) VB = 3
      IF ((V.GE.40).AND.(V.LT.50)) VB = 4
      IF ((V.GE.50).AND.(V.LT.60)) VB = 5
      IF ((V.GE.60).AND.(V.LT.70)) VB = 6
      IF (V.GE.70)                 VB = 7

      RETURN
      END

C *******************************************************************
C      ********************  END PROGRAM  *********************
C *******************************************************************
```

A.2.4 Load and Speed-based Emissions Binning Program EMLOAD.FOR

```
C ********************************************************************
C
C     PROGRAM EMLOAD (EMISSIONS BINING PROGRAM BASED ON LOAD MODES)
C     MARCH 15, 1993    VER. 1.0
C
C ********************************************************************
C
C     THIS PROGRAM WRITTEN BY:
C         MICHAEL J. ST. DENIS
C         ATMOSPHERIC INNOVATIVE RESEARCH
C         5025 DENNY AVENUE, #6
C         NORTH HOLLYWOOD, CA 91601
C         (818) 761-6048
C
C     WRITTEN FOR AND PROPERTY OF:
C         THE SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
C         21865 EAST COPELY DRIVE
C         DIAMOND BAR, CA 91765
C
C ********************************************************************
C
C     THIS PROGRAM READS IN A .DRW DATA FILE WHICH HAS BEEN
C     CONVERTED TO AN .AEU DATA FILE (ASCII) BY THE PROGRAM
C     V5CVT.EXE, AND USES THE LOAD THE VEHICLE IS IN TO DETERMINE
C     THE MODE THE VEHICLE IS IN
C     AND FROM THE EMISSIONS FILE DETERMINE THE EMISSIONS OF
C     HC, CO AND NOX AND ASSIGNS THEM TO THE LOAD BASED MODE.  THE
C     AVERAGE EMISSIONS FOR EACH LOAD BASED MODE IS THEN CALCULATED AND
C     WRITTEN TO A FILE FOR VIEWING AND ANOTHER FOR USE IN EMISSIONS
C     MODELING.
C
C ********************************************************************
C
C     VARIABLE DECLARATION SECTION:
C
C
C     VARIABLE ARRAYS ARE DEFINED AS FOLLOWS...
C
C         RT(X,Y)   WHERE...
C
C         R = EMISSIONS COMPOUND
C           H - HYDROCARBON
C           C - CARBON MONOXIDE
C           N - OXIDES OF NITROGEN
C
C         T = VARIABLE TYPE
C           N - SAMPLE NUMBER
C           S - SUM
C           Q - SUM OF SQUARES
C           A - AVERAGE
C           D - STANDARD DEVIATION
C
C         X = LOAD BASED MODE
C           0 - COLD START    ( COOLANT TEMP < 160 )
C           1 - HOT START     ( COOLANT TEMP >= 160 )
C           2 - OPEN LOOP RICH
C           3 - OPEN LOOP LEAN
```

```
C           4 - HIGH LOAD     ( 0.65 < LOAD)
C           5 - MEDIUM LOAD   ( 0.40 < LOAD <= 0.65 )
C           6 - LOW LOAD      ( LOAD <= 0.40 )
C
C         Y = VELOCITY RANGE
C           0 - 0  TO 10 MPH
C           1 - 10 TO 20 MPH
C           2 - 20 TO 30 MPH
C           3 - 30 TO 40 MPH
C           4 - 40 TO 50 MPH
C           5 - 50 TO 60 MPH
C           6 - 60 TO 70 MPH
C           7 - 70 MPH PLUS
C
C      OTHER VARIABLES
C
C       HCMASS - MASS HYDROCARBON READ IN
C       COMASS - MASS CARBON MONOXIDE READ IN
C       NOMASS - MASS NOx READ IN
C
C       VDASIN - FILE WITH VDAS DATA
C       EMISIN - FILE WITH EMISSIONS DATA
C       EMISOT - FILE TO WRITE FOR VIEWING
C       EMISMD - FILE TO WRITE AS INPUT TO EMISSIONS PREDICTING MODEL
C
C ******************************************************************


C *************  VARIABLE DECLARATION SECTION  ****************

      REAL  HN(0:6,0:7), HS(0:6,0:7), HQ(0:6,0:7)
      REAL  HA(0:6,0:7), HD(0:6,0:7)
      REAL  CN(0:6,0:7), CS(0:6,0:7), CQ(0:6,0:7)
      REAL  CA(0:6,0:7), CD(0:6,0:7)
      REAL  NN(0:6,0:7), NS(0:6,0:7), NQ(0:6,0:7)
      REAL  NA(0:6,0:7), ND(0:6,0:7)

      REAL  HCMASS, COMASS, NOMASS

      real  a(400)

      INTEGER  Z, START, I, VB
      INTEGER  getnum, getlab

      CHARACTER*40   VDASIN, EMISIN, EMISOT, EMISMD
      character*400  header

C *********************************************************
C       **********   BEGIN MAIN PROGRAM  ***********
C *********************************************************

C ************  READ IN FILE NAMES FOR I/O  ************


      READ (*,'(A)') VDASIN
      READ (*,'(A)') EMISIN
      READ (*,'(A)') EMISOT
      READ (*,'(A)') EMISMD
      OPEN (3, FILE = VDASIN)
      OPEN (7, FILE = EMISIN)
      OPEN (4, FILE = EMISOT)
```

```
      OPEN (2, FILE = EMISMD)

C **********  PRESET ARRAY VARIABLES TO ZERO  ***************

      START = 0

      DO 20 M = 0, 6, 1
       DO 10 V = 0, 7, 1

      HN(M,V)=0
      HS(M,V)=0
      HQ(M,V)=0
      CN(M,V)=0
      CS(M,V)=0
      CQ(M,V)=0
      NN(M,V)=0
      NS(M,V)=0
      NQ(M,V)=0

10    CONTINUE
20    CONTINUE

C ***************  BEGIN MAIN CALCULATIONS  ****************

      READ (3,'(a)')header

c get # of channels
      ilen=getnum(header)

c get indices of variables needed
      ispeed=getlab('vs',header)
      iolf=getlab('olflg',header)
      iload=getlab('load',header)
      iect=getlab('ect',header)
      iaf=getlab('lambda',header)

      DO 100 I = 1, 1000000, 1

C ******************  READ IN THE VDAS DATA AND  *******************
C ****************  READ IN THE MASS OF EMISSIONS  *****************

      READ (3,*,END=120) (a(k),k=1,ilen)
      READ (7,80,END=120) HCMASS, COMASS, NOMASS
80      FORMAT (T37,F5.0,T60,F5.0,T83,F5.0)

C *****************  LOAD BASED MODAL ANALYSIS  ********************

      IF (((I.EQ.1).AND.(A(IOLF).EQ.1)).OR.((START.EQ.1).AND.
     >     (A(IOLF).EQ.1))) THEN
           START = 1
        ELSE
           START = 0
      ENDIF
```

```
      IF ((START.EQ.1).AND.(A(IECT).LT.160)) THEN
        Y = 0
        Z = VB(A(ISPEED))
      ENDIF
      IF ((START.EQ.1).AND.(A(IECT).GE.160)) THEN
        Y = 1
        Z = VB(A(ISPEED))
      ENDIF
      IF ((START.EQ.0).AND.(A(IOLF).EQ.1).AND.
     >      (A(IAF).LE.1)) THEN
        Y = 2
        Z = VB(A(ISPEED))
      ENDIF
      IF ((START.EQ.0).AND.(A(IOLF).EQ.1).AND.
     >      (A(IAF).GT.1)) THEN
        Y = 3
        Z = VB(A(ISPEED))
      ENDIF
      IF ((START.EQ.0).AND.(A(IOLF).EQ.0).AND.
     >      (A(ILOAD).GT.(0.65))) THEN
        Y = 4
        Z = VB(A(ISPEED))
      ENDIF
      IF ((START.EQ.0).AND.(A(IOLF).EQ.0).AND.
     >       (A(ILOAD).GT.(0.40)).AND.(A(ILOAD).LE.(0.65))) THEN
        Y = 5
        Z = VB(A(ISPEED))
       ENDIF
       IF ((START.EQ.0).AND.(A(IOLF).EQ.0).AND.
     >     (A(ILOAD).LE.(0.40))) THEN
        Y = 6
        Z = VB(A(ISPEED))
      ENDIF
```

```
C  **  ASSIGN EMISSIONS TO LOAD BASED MODES   **

      HN(Y,Z) = HN(Y,Z) + 1
      HS(Y,Z) = HS(Y,Z) + HCMASS
      HQ(Y,Z) = HQ(Y,Z) + (HCMASS*HCMASS)
      CN(Y,Z) = CN(Y,Z) + 1
      CS(Y,Z) = CS(Y,Z) + COMASS
      CQ(Y,Z) = CQ(Y,Z) + (COMASS*COMASS)
      NN(Y,Z) = NN(Y,Z) + 1
      NS(Y,Z) = NS(Y,Z) + NOMASS
      NQ(Y,Z) = NQ(Y,Z) + (NOMASS*NOMASS)

100   CONTINUE
120   CONTINUE


C ***************  STATISTICAL CALCULATIONS  ****************


      DO 160 M = 0, 6, 1
       DO 140 V = 0, 7, 1

      IF (HN(M,V).EQ.0) THEN
        HA(M,V) = -9.9999
        HS(M,V) = -9.9999
C           HD(M,V) = -9.9999
      ELSEIF (HN(M,V).LT.2) THEN
        HA(M,V)=HS(M,V)/HN(M,V)
C           HD(M,V) = -9.9999
      ELSE
        HA(M,V)=HS(M,V)/HN(M,V)
C           HD(M,V)=SQRT((HQ(M,V)-(HS(M,V)*HS(M,V))/HN(M,V))
C     >        /(HN(M,V)-1))
      ENDIF

      IF (CN(M,V).EQ.0) THEN
        CA(M,V) = -9.9999
        CS(M,V) = -9.9999
C           CD(M,V) = -9.9999
      ELSEIF (CN(M,V).LT.2) THEN
        CA(M,V)=CS(M,V)/CN(M,V)
C           CD(M,V) = -9.9999
      ELSE
        CA(M,V)=CS(M,V)/CN(M,V)
C           CD(M,V)=SQRT((CQ(M,V)-(CS(M,V)*CS(M,V))/CN(M,V))
C     >        /(CN(M,V)-1))
      ENDIF

      IF (NN(M,V).EQ.0) THEN
        NA(M,V) = -9.9999
        NS(M,V) = -9.9999
C           ND(M,V) = -9.9999
      ELSEIF (NN(M,V).LT.2) THEN
        NA(M,V)=NS(M,V)/NN(M,V)
C           ND(M,V) = -9.9999
      ELSE
        NA(M,V)=NS(M,V)/NN(M,V)
C           ND(M,V)=SQRT((NQ(M,V)-(NS(M,V)*NS(M,V))/NN(M,V))
C     >        /(NN(M,V)-1))
      ENDIF
```

```
140   CONTINUE
160   CONTINUE

C ************  WRITE RESULTS TO VIEWING OUTFILE  ************

      WRITE (4,*) ' '
      WRITE (4,*) '  '
      WRITE (4,*) 'MASS EMISSIONS BY LOAD CALCULATIONS'
      WRITE (4,*) ' '
      WRITE (4,*) '  '
      WRITE (4,200) VDASIN
200   FORMAT ('     VDAS data file:      ', A12)
      WRITE (4,220) EMISIN
220   FORMAT ('     Emissions data file: ', A12)
      WRITE (4,*) '______________________________________________',
     >            '_______________________________________'
      WRITE (4,*) '  '
      WRITE (4,*) '  '
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) 'HC Mass Emissions by Load (g/sec):  '
      WRITE (4,*) '  '
      WRITE (4,*) 'Load              0-10    10-20    20-30    30-40',
     >            '    40-50    50-60    60-70    70+'
      WRITE (4,*) '----------------------------------------',
     >            '----------------------------------'
      WRITE (4,400) 'Cold Start   : ', HA(0,0),HA(0,1),HA(0,2),
     >  HA(0,3),HA(0,4),HA(0,5),HA(0,6),HA(0,7)
      WRITE (4,400) 'Hot Start    : ', HA(1,0),HA(1,1),HA(1,2),
     >  HA(1,3),HA(1,4),HA(1,5),HA(1,6),HA(1,7)
      WRITE (4,400) 'Rich OL      : ', HA(2,0),HA(2,1),HA(2,2),
     >  HA(2,3),HA(2,4),HA(2,5),HA(2,6),HA(2,7)
      WRITE (4,400) 'Lean OL      : ', HA(3,0),HA(3,1),HA(3,2),
     >  HA(3,3),HA(3,4),HA(3,5),HA(3,6),HA(3,7)
      WRITE (4,400) 'High Load    : ', HA(4,0),HA(4,1),HA(4,2),
     >  HA(4,3),HA(4,4),HA(4,5),HA(4,6),HA(4,7)
      WRITE (4,400) 'Medium Load  : ', HA(5,0),HA(5,1),HA(5,2),
     >  HA(5,3),HA(5,4),HA(5,5),HA(5,6),HA(5,7)
      WRITE (4,400) 'Low Load     : ', HA(6,0),HA(6,1),HA(6,2),
     >  HA(6,3),HA(6,4),HA(6,5),HA(6,6),HA(6,7)
      WRITE (4,*) '  '
      WRITE (4,*) '  '
      WRITE (4,*) '  '
      WRITE (4,*) '  '
      WRITE (4,*) ' '
      WRITE (4,*) 'CO Mass Emissions by Load (g/sec):  '
      WRITE (4,*) '  '
      WRITE (4,*) 'Load              0-10    10-20    20-30    30-40',
     >            '    40-50    50-60    60-70    70+'
      WRITE (4,*) '----------------------------------------',
     >            '---------------------------------'
      WRITE (4,400) 'Cold Start   : ', CA(0,0),CA(0,1),CA(0,2),
     >  CA(0,3),CA(0,4),CA(0,5),CA(0,6),CA(0,7)
      WRITE (4,400) 'Hot Start    : ', CA(1,0),CA(1,1),CA(1,2),
     >  CA(1,3),CA(1,4),CA(1,5),CA(1,6),CA(1,7)
      WRITE (4,400) 'Rich OL      : ', CA(2,0),CA(2,1),CA(2,2),
     >  CA(2,3),CA(2,4),CA(2,5),CA(2,6),CA(2,7)
      WRITE (4,400) 'Lean OL      : ', CA(3,0),CA(3,1),CA(3,2),
     >  CA(3,3),CA(3,4),CA(3,5),CA(3,6),CA(3,7)
```

```
      WRITE (4,400) 'High Load   : ', CA(4,0),CA(4,1),CA(4,2),
     >  CA(4,3),CA(4,4),CA(4,5),CA(4,6),CA(4,7)
      WRITE (4,400) 'Medium Load : ', CA(5,0),CA(5,1),CA(5,2),
     >  CA(5,3),CA(5,4),CA(5,5),CA(5,6),CA(5,7)
      WRITE (4,400) 'Low Load    : ', CA(6,0),CA(6,1),CA(6,2),
     >  CA(6,3),CA(6,4),CA(6,5),CA(6,6),CA(6,7)
      WRITE (4,*) '  '
      WRITE (4,*) '  '
      WRITE (4,*) '  '
      WRITE (4,*) '  '
      WRITE (4,*) ' '
      WRITE (4,*) 'NOx Mass Emissions by Load (g/sec):  '
      WRITE (4,*) '  '
      WRITE (4,*) 'Load              0-10    10-20    20-30    30-40',
     >            '    40-50    50-60    60-70     70+'
      WRITE (4,*) '---------------------------------------------',
     >            '-----------------------------------'
      WRITE (4,400) 'Cold Start  : ', NA(0,0),NA(0,1),NA(0,2),
     >  NA(0,3),NA(0,4),NA(0,5),NA(0,6),NA(0,7)
      WRITE (4,400) 'Hot Start   : ', NA(1,0),NA(1,1),NA(1,2),
     >  NA(1,3),NA(1,4),NA(1,5),NA(1,6),NA(1,7)
      WRITE (4,400) 'Rich OL     : ', NA(2,0),NA(2,1),NA(2,2),
     >  NA(2,3),NA(2,4),NA(2,5),NA(2,6),NA(2,7)
      WRITE (4,400) 'Lean OL     : ', NA(3,0),NA(3,1),NA(3,2),
     >  NA(3,3),NA(3,4),NA(3,5),NA(3,6),NA(3,7)
      WRITE (4,400) 'High Load   : ', NA(4,0),NA(4,1),NA(4,2),
     >  NA(4,3),NA(4,4),NA(4,5),NA(4,6),NA(4,7)
      WRITE (4,400) 'Medium Load : ', NA(5,0),NA(5,1),NA(5,2),
     >  NA(5,3),NA(5,4),NA(5,5),NA(5,6),NA(5,7)
      WRITE (4,400) 'Low Load    : ', NA(6,0),NA(6,1),NA(6,2),
     >  NA(6,3),NA(6,4),NA(6,5),NA(6,6),NA(6,7)

400   FORMAT (' ', A12, 8F8.4)


C **********  WRITE RAW DATA TO OUTPUT SAVE FILE  **********


      DO 410 M = 0, 6, 1
       DO 405 V = 0, 7, 1

      WRITE (2,500) HN(M,V), HS(M,V), HD(M,V)

405   CONTINUE
410   CONTINUE

      DO 430 M = 0, 6, 1
       DO 420 V = 0, 7, 1

      WRITE (2,500) CN(M,V), CS(M,V), CD(M,V)

420   CONTINUE
430   CONTINUE

      DO 450 M = 0, 6, 1
       DO 440 V = 0, 7, 1

      WRITE (2,500) NN(M,V), NS(M,V), ND(M,V)

440   CONTINUE
450   CONTINUE
```

```
500   FORMAT (' ',3F15.6)

      END

C ******************************************************************
C      ****************  END MAIN PROGRAM  *********************
C ******************************************************************

C ******************************************************************
C      ******************   FUNCTIONS  **********************
C ******************************************************************

C  *****  FUNCTION GETLAB  *****

c  by G. Jesion, Ford Motor Company
c  Copyrite, 1991

      integer function getlab(lab,list)
      character *(*) lab,list
      character*20 test

      index=1
      do i=1,40
        test='                    '
        do j=1,40
          if(list(index:index).EQ.' ') then
            do k=1,40
            if(list(index:index).NE.' ') go to 10
            index=index+1
            enddo
          endif
          test(j:j)=list(index:index)
          index=index+1
        enddo
10        continue
        if(test.EQ.lab) then
          getlab=i
          return
        endif
      enddo
      print *,lab,' not found!'
      stop
      return
      end

C  *****  FUNCTION GETNUM  *****

      integer function getnum(t)
      character*(*) t
      index=1
      iword=0
      isspace=1
      do i=1,400
        if(t(index:index).NE.' ') then
          isspace=0
        else
          if(isspace.EQ.0) then
            iword=iword+1
            isspace=1
          endif
        endif
```

```
        index=index+1
      enddo
      getnum=iword
      return
      end

C  *****  FUNCTION VELBIN  *****

      INTEGER FUNCTION VB(V)

      REAL V

      IF ((V.GE.0).AND.(V.LT.10))  VB = 0
      IF ((V.GE.10).AND.(V.LT.20)) VB = 1
      IF ((V.GE.20).AND.(V.LT.30)) VB = 2
      IF ((V.GE.30).AND.(V.LT.40)) VB = 3
      IF ((V.GE.40).AND.(V.LT.50)) VB = 4
      IF ((V.GE.50).AND.(V.LT.60)) VB = 5
      IF ((V.GE.60).AND.(V.LT.70)) VB = 6
      IF (V.GE.70)                 VB = 7

      RETURN
      END

C ********************************************************************
C      ********************  END PROGRAM  *********************
C ********************************************************************
```

A.2.5 Load and Speed-based Emissions Averaging Program AVGL.FOR

```
C *********************************************************************
C
C     PROGRAM AVEL (AVERAGE EMISSIONS FROM LOAD ESTIMATION PROGRAMS)
C     MARCH 22, 1993    VER. 1.0
C
C *********************************************************************
C
C     THIS PROGRAM WRITTEN BY:
C         MICHAEL J. ST. DENIS
C         ATMOSPHERIC INNOVATIVE RESEARCH
C         5025 DENNY AVENUE, #6
C         NORTH HOLLYWOOD, CA 91601
C         (818) 761-6048
C
C     WRITTEN FOR AND PROPERTY OF:
C         THE SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
C         21865 EAST COPELY DRIVE
C         DIAMOND BAR, CA 91765
C
C *********************************************************************
C
C     THIS PROGRAM READS IN A VARIABLE NUMBER OF BINNED LOAD BASED
C     EMISSIONS FILES, AND AVERAGES THE EMISSIONS IN EACH BIN.  THE
C     OUTPUT FILE CONTAINS THE AVERAGED EMISSIONS FOR EACH BIN FOR
C     USE IN ESTIMATING ON-ROAD EMISSIONS.
C
C *********************************************************************
C
C     VARIABLE DECLARATION SECTION:
C
C
C     VARIABLE ARRAYS ARE DEFINED AS FOLLOWS...
C
C         RT(X,Y)  WHERE...
C
C         R = EMISSIONS COMPOUND
C           H - HYDROCARBON
C           C - CARBON MONOXIDE
C           N - OXIDES OF NITROGEN
C
C         T = VARIABLE TYPE
C           N - SAMPLE NUMBER
C           S - SUM
C           A - AVERAGE
C
C         X = LOAD BASED MODE
C           0 - COLD START    ( COOLANT TEMP < 160 )
C           1 - HOT START     ( COOLANT TEMP >= 160 )
C           2 - OPEN LOOP RICH
C           3 - OPEN LOOP LEAN
C           4 - HIGH LOAD     ( 0.65 < LOAD)
C           5 - MEDIUM LOAD   ( 0.40 < LOAD <= 0.65 )
C           6 - LOW LOAD      ( LOAD <= 0.40 )
C
C         Y = VELOCITY RANGE
C           0 - 0  TO 10 MPH
C           1 - 10 TO 20 MPH
```

```
C           2 - 20 TO 30 MPH
C           3 - 30 TO 40 MPH
C           4 - 40 TO 50 MPH
C           5 - 50 TO 60 MPH
C           6 - 60 TO 70 MPH
C           7 - 70 MPH PLUS
C
C      OTHER VARIABLES
C
C       MASS - MASS POLLUTANT READ IN
C       NUM  - NUMBER OF MEASUREMENTS IN EACH BIN
C       VDASIN - FILE WITH VDAS DATA
C       EMISIN - FILE WITH BINNED EMISSIONS DATA
C       EMISVW - FILE TO WRITE FOR VIEWING
C       EMISOT - FILE TO WRITE FOR INPUT TO ESTIMATION MODEL
C
C ********************************************************************


C *************  VARIABLE DECLARATION SECTION  ****************

      REAL  HS(0:6,0:7), CS(0:6,0:7), NS(0:6,0:7)
      REAL  HN(0:6,0:7), CN(0:6,0:7), NN(0:6,0:7)
      REAL  HA(0:6,0:7), CA(0:6,0:7), NA(0:6,0:7)

      REAL  NUM, MASS

      INTEGER  M, V

      CHARACTER*40   EMISFL, EMISIN, EMISOT, EMISVW

C *******************************************************
C       **********   BEGIN MAIN PROGRAM  ***********
C *******************************************************

C ************  READ IN FILE NAMES FOR I/O  ************


      READ (*,'(A)') EMISFL
      READ (*,'(A)') EMISVW
      READ (*,'(A)') EMISOT
      OPEN (7, FILE = EMISFL)
      OPEN (4, FILE = EMISVW)
      OPEN (5, FILE = EMISOT)


C **********  PRESET VARIABLES  ***************


      DO 2 M = 0, 6, 1
       DO 1 V = 0, 7, 1

      HN(M,V) = 0
      CN(M,V) = 0
      NN(M,V) = 0

      HS(M,V) = 0
      CS(M,V) = 0
      NS(M,V) = 0

1     CONTINUE
```

```
2     CONTINUE

C ***************  BEGIN MAIN CALCULATIONS  ****************

C ****************  READ IN THE MASS OF EMISSIONS  *****************

      DO 900 I = 0, 1000000, 1
      READ (7,'(A)',END=950) EMISIN
      OPEN (3, FILE = EMISIN)

      DO 20 M = 0, 6, 1
       DO 10 V = 0, 7, 1

       READ (3,80,END=30) NUM, MASS
       IF (NUM.GE.0.5) THEN
       HN(M,V) = NUM  + HN(M,V)
       HS(M,V) = MASS + HS(M,V)
       ENDIF

10     CONTINUE
20    CONTINUE
30    CONTINUE

      DO 21 M = 0, 6, 1
       DO 11 V = 0, 7, 1

       READ (3,80,END=31) NUM, MASS
       IF (NUM.GE.0.5) THEN
       CN(M,V) = NUM  + CN(M,V)
       CS(M,V) = MASS + CS(M,V)
       ENDIF

11     CONTINUE
21    CONTINUE
31    CONTINUE

      DO 22 M = 0, 6, 1
       DO 12 V = 0, 7, 1

       READ (3,80,END=32) NUM, MASS
       IF (NUM.GE.0.5) THEN
       NN(M,V) = NUM  + NN(M,V)
       NS(M,V) = MASS + NS(M,V)
       ENDIF

12     CONTINUE
22    CONTINUE
32    CONTINUE

80     FORMAT (2F15.6)

       CLOSE (3)

900   CONTINUE
950   CONTINUE

C ***************  STATISTICAL CALCULATIONS  ****************

      DO 160 M = 0, 6, 1
       DO 140 V = 0, 7, 1
```

```
      IF (HN(M,V).LT.0.5) THEN
        HA(M,V) = -9.999
      ELSE
        HA(M,V) = HS(M,V) / HN(M,V)
      ENDIF

      IF (CN(M,V).LT.0.5) THEN
        CA(M,V) = -9.999
      ELSE
        CA(M,V) = CS(M,V) / CN(M,V)
      ENDIF

      IF (NN(M,V).LT.0.5) THEN
        NA(M,V) = -9.999
      ELSE
        NA(M,V) = NS(M,V) / NN(M,V)
      ENDIF

140    CONTINUE
160   CONTINUE

C ************  WRITE RESULTS TO VIEW FILE  ************

      WRITE (4,*) ' '
      WRITE (4,*) '  '
      WRITE (4,*) 'AVG MASS EMISSIONS BY LOAD CALCULATIONS'
      WRITE (4,*) '  '
      WRITE (4,200) EMISFL
200   FORMAT ('      Emissions data files list:       ', A12)
      WRITE (4,220) EMISOT
220   FORMAT ('      Emissions output data file:      ', A12)
      WRITE (4,*) '_____________________________________________',
     >            '_____________________________________'
      WRITE (4,*) '  '
      WRITE (4,*) '  '
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) ' '
      WRITE (4,*) 'HC Mass Emissions by Load (g/sec):  '
      WRITE (4,*) '  '
      WRITE (4,*) 'Load              0-10   10-20   20-30   30-40',
     >            '   40-50   50-60   60-70    70+'
      WRITE (4,*) '-----------------------------------------',
     >            '---------------------------------'
      WRITE (4,400) 'Cold Start  : ', HA(0,0),HA(0,1),HA(0,2),
     >  HA(0,3),HA(0,4),HA(0,5),HA(0,6),HA(0,7)
      WRITE (4,400) 'Hot Start   : ', HA(1,0),HA(1,1),HA(1,2),
     >  HA(1,3),HA(1,4),HA(1,5),HA(1,6),HA(1,7)
      WRITE (4,400) 'Rich OL     : ', HA(2,0),HA(2,1),HA(2,2),
     >  HA(2,3),HA(2,4),HA(2,5),HA(2,6),HA(2,7)
      WRITE (4,400) 'Lean OL     : ', HA(3,0),HA(3,1),HA(3,2),
     >  HA(3,3),HA(3,4),HA(3,5),HA(3,6),HA(3,7)
      WRITE (4,400) 'High Load   : ', HA(4,0),HA(4,1),HA(4,2),
     >  HA(4,3),HA(4,4),HA(4,5),HA(4,6),HA(4,7)
      WRITE (4,400) 'Medium Load : ', HA(5,0),HA(5,1),HA(5,2),
     >  HA(5,3),HA(5,4),HA(5,5),HA(5,6),HA(5,7)
      WRITE (4,400) 'Low Load    : ', HA(6,0),HA(6,1),HA(6,2),
     >  HA(6,3),HA(6,4),HA(6,5),HA(6,6),HA(6,7)
      WRITE (4,*) '  '
      WRITE (4,*) '  '
      WRITE (4,*) '  '
```

```
      WRITE (4,*) '  '
      WRITE (4,*) ' '
      WRITE (4,*) 'CO Mass Emissions by Load (g/sec):  '
      WRITE (4,*) '  '
      WRITE (4,*) 'Load             0-10   10-20   20-30   30-40',
     >            '   40-50   50-60   60-70    70+'
      WRITE (4,*) '----------------------------------------',
     >            '----------------------------------'
      WRITE (4,400) 'Cold Start  : ', CA(0,0),CA(0,1),CA(0,2),
     >  CA(0,3),CA(0,4),CA(0,5),CA(0,6),CA(0,7)
      WRITE (4,400) 'Hot Start   : ', CA(1,0),CA(1,1),CA(1,2),
     >  CA(1,3),CA(1,4),CA(1,5),CA(1,6),CA(1,7)
      WRITE (4,400) 'Rich OL     : ', CA(2,0),CA(2,1),CA(2,2),
     >  CA(2,3),CA(2,4),CA(2,5),CA(2,6),CA(2,7)
      WRITE (4,400) 'Lean OL     : ', CA(3,0),CA(3,1),CA(3,2),
     >  CA(3,3),CA(3,4),CA(3,5),CA(3,6),CA(3,7)
      WRITE (4,400) 'High Load   : ', CA(4,0),CA(4,1),CA(4,2),
     >  CA(4,3),CA(4,4),CA(4,5),CA(4,6),CA(4,7)
      WRITE (4,400) 'Medium Load : ', CA(5,0),CA(5,1),CA(5,2),
     >  CA(5,3),CA(5,4),CA(5,5),CA(5,6),CA(5,7)
      WRITE (4,400) 'Low Load    : ', CA(6,0),CA(6,1),CA(6,2),
     >  CA(6,3),CA(6,4),CA(6,5),CA(6,6),CA(6,7)
      WRITE (4,*) '  '
      WRITE (4,*) '  '
      WRITE (4,*) '  '
      WRITE (4,*) '  '
      WRITE (4,*) ' '
      WRITE (4,*) 'NOx Mass Emissions by Load (g/sec):  '
      WRITE (4,*) '  '
      WRITE (4,*) 'Load             0-10   10-20   20-30   30-40',
     >            '   40-50   50-60   60-70    70+'
      WRITE (4,*) '----------------------------------------',
     >            '----------------------------------'
      WRITE (4,400) 'Cold Start  : ', NA(0,0),NA(0,1),NA(0,2),
     >  NA(0,3),NA(0,4),NA(0,5),NA(0,6),NA(0,7)
      WRITE (4,400) 'Hot Start   : ', NA(1,0),NA(1,1),NA(1,2),
     >  NA(1,3),NA(1,4),NA(1,5),NA(1,6),NA(1,7)
      WRITE (4,400) 'Rich OL     : ', NA(2,0),NA(2,1),NA(2,2),
     >  NA(2,3),NA(2,4),NA(2,5),NA(2,6),NA(2,7)
      WRITE (4,400) 'Lean OL     : ', NA(3,0),NA(3,1),NA(3,2),
     >  NA(3,3),NA(3,4),NA(3,5),NA(3,6),NA(3,7)
      WRITE (4,400) 'High Load   : ', NA(4,0),NA(4,1),NA(4,2),
     >  NA(4,3),NA(4,4),NA(4,5),NA(4,6),NA(4,7)
      WRITE (4,400) 'Medium Load : ', NA(5,0),NA(5,1),NA(5,2),
     >  NA(5,3),NA(5,4),NA(5,5),NA(5,6),NA(5,7)
      WRITE (4,400) 'Low Load    : ', NA(6,0),NA(6,1),NA(6,2),
     >  NA(6,3),NA(6,4),NA(6,5),NA(6,6),NA(6,7)

400   FORMAT (' ', A12, 8F8.4)

C ************  WRITE RESULTS TO OUTFILE  ************

      DO 410 M = 0, 6, 1
       DO 405 V = 0, 7, 1

      WRITE (5,500) HA(M,V)

405   CONTINUE
410   CONTINUE

      DO 430 M = 0, 6, 1
```

```
       DO 420 V = 0, 7, 1

      WRITE (5,500) CA(M,V)

420   CONTINUE
430   CONTINUE

      DO 450 M = 0, 6, 1
       DO 440 V = 0, 7, 1

      WRITE (5,500) NA(M,V)

440   CONTINUE
450   CONTINUE

500   FORMAT (' ',F15.6)

      END

C ********************************************************************
C      ****************  END MAIN PROGRAM  *********************
C *********************************************************************
```

A.2.6 Load and Speed-based Emissions Estimating Program LOADIO.FOR

```
C ********************************************************************
C
C     PROGRAM LOADIO (EMISSIONS ESTIMATION PROGRAM BASED ON LOAD MODES)
C     MARCH 19, 1993    VER. 1.0
C
C ********************************************************************
C
C     THIS PROGRAM WRITTEN BY:
C         MICHAEL J. ST. DENIS
C         ATMOSPHERIC INNOVATIVE RESEARCH
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C
C     WRITTEN FOR AND PROPERTY OF:
C         THE SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
C         21865 EAST COPELY DRIVE
C         DIAMOND BAR, CA 91765
C
C ********************************************************************
C
C     THIS PROGRAM READS IN AN ON-ROAD VDAS .DRW DATA FILE WHICH HAS BEEN
C     CONVERTED TO AN .AEU DATA FILE (ASCII) BY THE PROGRAM
C     V5CVT.EXE, AND CALCULATES THE FREQUENCY OF THE MODE THE VEHICLE
C     IS IN AND USES AN AVERAGE EMISSIONS FILE TO CALCULATE THE ON-ROAD
C     EMISSIONS OF HC, CO, AND NOX AS A FUNCTION OF TIME AND OF
C     DISTANCE TRAVELED.
C
C ********************************************************************
C
C     VARIABLE DECLARATION SECTION:
C
C
C     VARIABLE ARRAYS ARE DEFINED AS FOLLOWS...
C
C         RT(X,Y)  WHERE...
C
C         R = EMISSIONS COMPOUND
C           H - HYDROCARBON
C           C - CARBON MONOXIDE
C           N - OXIDES OF NITROGEN
C
C         T = VARIABLE TYPE
C           A - AVERAGE
C
C         X = LOAD BASED MODE
C           0 - COLD START   ( COOLANT TEMP < 160 )
C           1 - HOT START    ( COOLANT TEMP >= 160 )
C           2 - OPEN LOOP RICH
C           3 - OPEN LOOP LEAN
C           4 - HIGH LOAD    ( 0.65 < LOAD)
C           5 - MEDIUM LOAD  ( 0.40 < LOAD <= 0.65 )
C           6 - LOW LOAD     ( LOAD <= 0.40 )
C
C         Y = VELOCITY RANGE
C           0 - 0  TO 10 MPH
C           1 - 10 TO 20 MPH
```

```
C           2 - 20 TO 30 MPH
C           3 - 30 TO 40 MPH
C           4 - 40 TO 50 MPH
C           5 - 50 TO 60 MPH
C           6 - 60 TO 70 MPH
C           7 - 70 MPH PLUS
C
C     OTHER VARIABLES
C
C      BININ  - FILE WITH BINNED, AVERAGED EMISSIONS DATA
C      CF     - SUM MASS OF CARBON MONOXIDE IN EMISSIONS FILE
C      CMERD  - CARBON MONOXIDE MASS EMISSIONS RATE, DISTANCE
C      CMERT  - CARBON MONOXIDE MASS EMISSIONS RATE, TIME
C      DIST   - DISTANCE TRAVELED
C      EMISOT - FILE TO WRITE FOR VIEWING
C      HF     - SUM MASS OF HYDROCARBON IN EMISSIONS FILE
C      HMERD  - HYDROCARBON MASS EMISSIONS RATE, DISTANCE
C      HMERT  - HYDROCARBON MASS EMISSIONS RATE, TIME
C      MASS   - MASS POLLUTANT READ IN
C      NF     - SUM MASS OF OXIDE OF NITROGEN IN EMISSIONS FILE
C      NMERD  - OXIDES OF NITROGEN MASS EMISSIONS RATE, DISTANCE
C      NMERT  - OXIDES OF NITROGEN MASS EMISSIONS RATE, TIME
C      NUM(XXX,YYY) - NUMBER OF OCCURRENCES ON MODE (XXX,YYY) ON-ROAD
C      OP     - FLAG AS TO WRITE OUTPUT FILE
C      START  - IS COLD START PRESENT
C      TIME   - TOTAL TIME ON-ROAD
C      VB     - FUNCTION TO DETERMINE VELOCITY BIN
C      VDASIN - FILE WITH VDAS DATA
C
C ********************************************************************

C *************  VARIABLE DECLARATION SECTION  ****************

      REAL  HA(0:6,0:7), CA(0:6,0:7), NA(0:6,0:7), NUM(0:6,0:7)

      REAL  MASS, DIST, HF, CF, NF
      REAL  HMERT, CMERT, NMERT, HMERD, CMERD, NMERD

      real  a(400)

      INTEGER  Z, START, I, VB, TIME, M, V, Y
      INTEGER  getnum, getlab, OP

      CHARACTER*40   VDASIN, BININ, EMISOT
      character*400  header

C *******************************************************
C       **********   BEGIN MAIN PROGRAM   ***********
C *******************************************************

C ************  READ IN FILE NAMES FOR I/O  ************


      READ (*,'(A)') VDASIN
      READ (*,'(A)') BININ
      READ (*,'(A)') EMISOT
      OPEN (3, FILE = VDASIN)
      OPEN (7, FILE = BININ)
      OPEN (4, FILE = EMISOT)
```

```
C **********  PRESET VARIABLES  ***************

      START = 0
      DIST = 0
      HF = 0
      CF = 0
      NF = 0
      OP = 1

      DO 2 M = 0, 6, 1
       DO 1 V = 0, 7, 1

      NUM(M,V) = 0

1     CONTINUE
2     CONTINUE

C ***************  BEGIN MAIN CALCULATIONS  ****************


      READ (3,'(a)')header

c get # of channels
      ilen=getnum(header)

c get indices of variables needed
      ispeed=getlab('vs',header)
      iolf=getlab('olflg',header)
      iload=getlab('load',header)
      iect=getlab('ect',header)
      iaf=getlab('lambda',header)

      DO 100 I = 1, 1000000, 1


C ******************  READ IN THE VDAS DATA AND  *******************
C ****************  READ IN THE MASS OF EMISSIONS  *****************

      READ (3,*,END=120) (a(k),k=1,ilen)

C *****************  LOAD BASED MODAL ANALYSIS  ********************

      DIST = DIST + (A(ISPEED) / 3600)

      IF (((I.EQ.1).AND.(A(IOLF).EQ.1)).OR.((START.EQ.1).AND.
     >     (A(IOLF).EQ.1))) THEN
          START = 1
        ELSE
          START = 0
      ENDIF

      IF ((START.EQ.1).AND.(A(IECT).LT.160)) THEN

        Y = 0
        Z = VB(A(ISPEED))
        NUM(Y,Z) = NUM(Y,Z) + 1

      ENDIF

      IF ((START.EQ.1).AND.(A(IECT).GE.160)) THEN
```

```
        Y = 1
        Z = VB(A(ISPEED))
        NUM(Y,Z) = NUM(Y,Z) + 1

      ENDIF

      IF ((START.EQ.0).AND.(A(IOLF).EQ.1).AND.
     >      (A(IAF).LE.1)) THEN

        Y = 2
        Z = VB(A(ISPEED))
        NUM(Y,Z) = NUM(Y,Z) + 1

      ENDIF

      IF ((START.EQ.0).AND.(A(IOLF).EQ.1).AND.
     >      (A(IAF).GT.1)) THEN

        Y = 3
        Z = VB(A(ISPEED))
        NUM(Y,Z) = NUM(Y,Z) + 1

      ENDIF

      IF ((START.EQ.0).AND.(A(IOLF).EQ.0).AND.
     >      (A(ILOAD).GT.(0.65))) THEN

        Y = 4
        Z = VB(A(ISPEED))
        NUM(Y,Z) = NUM(Y,Z) + 1

      ENDIF

      IF ((START.EQ.0).AND.(A(IOLF).EQ.0).AND.
     >       (A(ILOAD).GT.(0.40)).AND.(A(ILOAD).LE.(0.65))) THEN

        Y = 5
        Z = VB(A(ISPEED))
        NUM(Y,Z) = NUM(Y,Z) + 1

       ENDIF

       IF ((START.EQ.0).AND.(A(IOLF).EQ.0).AND.
     >     (A(ILOAD).LE.(0.40))) THEN

        Y = 6
        Z = VB(A(ISPEED))
        NUM(Y,Z) = NUM(Y,Z) + 1

      ENDIF

100   CONTINUE
120   CONTINUE

C ***************  READ IN BINNED EMISSIONS DATA  ****************

      DO 20 M = 0, 6, 1
       DO 10 V = 0, 7, 1

       READ (7,80,END=30) MASS
       HA(M,V) = MASS
```

```
10       CONTINUE
20      CONTINUE
30      CONTINUE

        DO 21 M = 0, 6, 1
         DO 11 V = 0, 7, 1

         READ (7,80,END=31) MASS
         CA(M,V) = MASS

11       CONTINUE
21      CONTINUE
31      CONTINUE

        DO 22 M = 0, 6, 1
         DO 12 V = 0, 7, 1

         READ (7,80,END=32) MASS
         NA(M,V) = MASS

12       CONTINUE
22      CONTINUE
32      CONTINUE

80       FORMAT (F15.6)

C ***************  STATISTICAL CALCULATIONS  ****************

        TIME = I-1

        DO 160 M = 0, 6, 1
         DO 140 V = 0, 7, 1

        IF ((NUM(M,V).GT.0).AND.(HA(M,V).LT.0)) THEN
         IF (OP.EQ.1) THEN
          WRITE (*,*) 'FATAL ERROR.'
          WRITE (*,*) ' '
          WRITE (*,*) 'Mode(s) in VDAS data file not found in ',
     >                 'emissions data, see output file. '
          WRITE (*,*) ' '
          WRITE (4,*) ' '
          WRITE (4,*) 'Modes were found in VDAS data but no',
     >                 ' emissions data were found.'
          WRITE (4,227) VDASIN
227         FORMAT (' VDAS data file: ', A40)
          WRITE (4,*) ' '
          WRITE (4,*) 'The modes are (load, velocity, % time): '
          WRITE (4,*) ' '
         ENDIF

         WRITE (4,67) M, V, ((100 * NUM(M,V))/time)
67         FORMAT (' ',I2,I2,' ',F10.6)

         OP = 0

        ENDIF

        HF = (HA(M,V) * NUM(M,V)) + HF
        CF = (CA(M,V) * NUM(M,V)) + CF
        NF = (NA(M,V) * NUM(M,V)) + NF
```

```
 140   CONTINUE
 160   CONTINUE

       HMERT = HF / TIME
       CMERT = CF / TIME
       NMERT = NF / TIME

       HMERD = HF / DIST
       CMERD = CF / DIST
       NMERD = NF / DIST


C ************  WRITE RESULTS TO VIEWING OUTFILE  ************

       IF (OP.EQ.1) THEN

        WRITE (4,*) ' '
        WRITE (4,*) '  '
        WRITE (4,*) 'MASS EMISSIONS BY LOAD CALCULATIONS'
        WRITE (4,*) ' '
        WRITE (4,*) '  '
        WRITE (4,200) VDASIN
200     FORMAT ('      VDAS data file:      ', A40)
        WRITE (4,220) BININ
220     FORMAT ('      Emissions data file: ', A40)
        WRITE (4,*) '________________________________________',
     >             '__________________________________'
        WRITE (4,*) '  '
        WRITE (4,410) TIME
410     FORMAT (' Driving time = ', I4, ' seconds.')
        WRITE (4,*) ' '
        WRITE (4,420) DIST
420     FORMAT (' Driving distance = ', F7.2, ' miles.')
        WRITE (4,*) '  '
        WRITE (4,*) '  '
        WRITE (4,*) '  '
        WRITE (4,*) 'Calculated Emitted Mass and Emission Rates:  '
        WRITE (4,*) '  '
        WRITE (4,*) 'Component                    total grams ',
     >             '      grams/sec       grams/mile'
        WRITE (4,*) '----------------------------------------',
     >             '--------------------------------'
        WRITE (4,400) HF, HMERT, HMERD
        WRITE (4,*) '  '
        WRITE (4,401) CF, CMERT, CMERD
        WRITE (4,*) '  '
        WRITE (4,402) NF, NMERT, NMERD
        WRITE (4,*) '  '
        WRITE (4,*) '  '

400     FORMAT (' Hydrocarbons       : ', 3F16.4)
401     FORMAT (' Carbon Monoxide    : ', 3F16.4)
402     FORMAT (' Oxides of Nitrogen : ', 3F16.4)

       ENDIF

       END

C *******************************************************************
C      ****************  END MAIN PROGRAM  *********************
C *******************************************************************
```

```
C ***********************************************************************
C       *******************   FUNCTIONS   ***********************
C ***********************************************************************

C  *****  FUNCTION GETLAB  *****

c  by G. Jesion, Ford Motor Company
c  Copyrite, 1991

      integer function getlab(lab,list)
      character *(*) lab,list
      character*20 test

      index=1
      do i=1,40
        test='                    '
        do j=1,40
          if(list(index:index).EQ.' ') then
            do k=1,40
            if(list(index:index).NE.' ') go to 10
            index=index+1
            enddo
          endif
          test(j:j)=list(index:index)
          index=index+1
        enddo
10        continue
        if(test.EQ.lab) then
          getlab=i
          return
        endif
      enddo
      print *,lab,' not found!'
      stop
      return
      end

C  *****  FUNCTION GETNUM  *****

      integer function getnum(t)
      character*(*) t
      index=1
      iword=0
      isspace=1
      do i=1,400
        if(t(index:index).NE.' ') then
          isspace=0
        else
          if(isspace.EQ.0) then
            iword=iword+1
            isspace=1
          endif
        endif
        index=index+1
      enddo
      getnum=iword
      return
      end

C  *****  FUNCTION VELBIN  *****
```

```
      INTEGER FUNCTION VB(V)

      REAL V

      IF ((V.GE.0).AND.(V.LT.10))  VB = 0
      IF ((V.GE.10).AND.(V.LT.20)) VB = 1
      IF ((V.GE.20).AND.(V.LT.30)) VB = 2
      IF ((V.GE.30).AND.(V.LT.40)) VB = 3
      IF ((V.GE.40).AND.(V.LT.50)) VB = 4
      IF ((V.GE.50).AND.(V.LT.60)) VB = 5
      IF ((V.GE.60).AND.(V.LT.70)) VB = 6
      IF (V.GE.70)                 VB = 7

      RETURN
      END

C ***********************************************************************
C      ********************  END PROGRAM  **********************
C ***********************************************************************
```

A.2.7 One Second Emissions Analysis Program EMOUT.FOR

```
C *********************************************************************
C
C       PROGRAM EMOUT (EMISSIONS SUMMING PROGRAM FROM DYNO MEASUREMENTS)
C       MARCH 23, 1993    VER. 1.0
C
C *********************************************************************
C
C       THIS PROGRAM WRITTEN BY:
C           MICHAEL J. ST. DENIS
C           ATMOSPHERIC INNOVATIVE RESEARCH
C           5025 DENNY AVENUE, #6
C           NORTH HOLLYWOOD, CA 91601
C           (818) 761-6048
C
C       WRITTEN FOR AND PROPERTY OF:
C           THE SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
C           21865 EAST COPELY DRIVE
C           DIAMOND BAR, CA 91765
C
C *********************************************************************
C
C       THIS PROGRAM READS IN A DATA FILE GENERATED BY THE DYNAMOMETER
C       COMPUTER AT FORD'S GTL LAB AND SUMS THE EMISSIONS FROM THE
C       EXPERIMENT AND OUTPUTS THE TOTAL MASSES OF HC, CO AND NOX,
C       DURING THE TEST.  THESE DATA ARE USED TO COMPARE THE ONE SECOND
C       EMISSIONS TO THE BAG EMISSIONS
C
C *********************************************************************
C
C       VARIABLE DECLARATION SECTION:
C
C        COMASS - INDIVIDUAL MASS OF CO IN ONE SECOND MEASUREMENT
C        CS     - SUM OF ALL ONE SECOND CO MASSES
C        HCMASS - INDIVIDUAL MASS OF HC IN ONE SECOND MEASUREMENT
C        HS     - SUM OF ALL ONE SECOND HC MASSES
C        I      - LOOP COUNTER
C        NOMASS - INDIVIDUAL MASS OF NOX IN ONE SECOND MEASUREMENT
C        NS     - SUM OF ALL ONE SECOND NOX MASSES
C
C *********************************************************************


C *************  VARIABLE DECLARATION SECTION  ****************

      REAL  HCMASS, COMASS, NOMASS
      REAL  HS, CS, NS
      INTEGER I

C *************  BEGIN PROGRAM  ****************

      HS = 0
      CS = 0
      NS = 0

      DO 100 I = 1, 1000000, 1

      READ (*,80,END=120) HCMASS, COMASS, NOMASS
```

```
80       FORMAT (T37,F5.0,T60,F5.0,T83,F5.0)
      HS = HS + HCMASS
      CS = CS + COMASS
      NS = NS + NOMASS

100   CONTINUE
120   CONTINUE

      WRITE (*,*) HS, CS, NS
      END

C *************  END PROGRAM  ****************
```

A.3 List of File Extension Definitions

AEU -	DRW file converted from binary to ascii by program V5CVT.
ASC -	Driving pattern data in ASCII with counter data.
ANL -	Analysis of non-smoothed data from ANLYSXX.FOR.
BIN -	Data file which has been binned by velocity, acceleration and probability by the program VABIN.FOR.
DOL -	Duration of open loop operation output file from data analysis program ANLYSXX.FOR.
DRW -	Data raw binary file collected by VDAS.
FOR -	Program source code for data analysis and modeling programs.
GM -	Analysis of VDAS data for percent time in GM enrichment mode.
HMA -	Data for input to emissions binning file from HZX file.
HZX -	Hertz (one second) data from Horiba system at FORD GTL dynamometer laboratory (X = emissions "bag" number).
LBN -	Load based binned emissions data for viewing.
LEM -	Load based binned emissions data for input to emissions estimation program.
LOE -	Load based estimated emissions for viewing.
MBN -	Mode based binned emissions data for viewing.
MEM -	Mode based binned emissions data for input to emissions estimation program.
MOE -	Mode based estimated emissions for viewing.
MOF -	Modal data output file from data analysis program ANLYSXX.FOR.
SMA -	Analysis of smoothed data from ANLYSXX.FOR.
SMT -	Smoothed data file from .AEU data file breaks filled in.
VAG -	Analysis of VDAS data by velocity, acceleration and gear.

A.4 Occurrences of Open Loop Operation On-Road

A.4.1 Repeated Freeway Experiment Lean Open Loop Events

Duration (sec)	Speed mph	Accel mph/s	Duration (sec)	Speed mph	Accel mph/s	Duration (sec)	Speed mph	Accel mph/s	Duration (sec)	Speed mph	Accel mph/s
1	43.73	-0.56	2	55.21	-0.71	4	53.54	-0.53	8	51.82	-0.35
1	43.87	-0.73	2	55.37	-3.08	4	53.97	-0.01	8	54.33	-0.29
1	44.21	-0.35	2	55.43	-0.48	4	54.17	-0.36	8	56.36	-0.30
1	44.57	-1.01	2	55.52	-0.98	4	54.49	-0.33	8	56.57	-0.32
1	45.51	-0.89	2	55.67	-0.39	4	54.61	-0.29	8	58.08	-0.75
1	45.83	-1.99	2	55.71	-0.61	4	54.69	-0.24	8	58.73	-0.97
1	46.25	-0.97	2	55.88	-0.26	4	54.80	-0.27	8	58.74	-0.30
1	46.84	-0.54	2	56.02	-0.66	4	55.36	-0.46	8	58.88	-0.49
1	47.36	-1.23	2	56.12	-0.43	4	55.50	-0.88	8	59.18	-0.52
1	47.50	-1.81	2	56.93	-0.55	4	56.28	-0.41	8	59.96	-0.44
1	47.57	-0.96	2	56.99	-0.39	4	56.80	-1.18	8	60.69	-0.66
1	47.79	-4.21	2	57.36	-0.24	4	57.73	-0.30	9	53.99	-0.25
1	48.59	-2.43	2	57.72	-0.43	4	58.40	-0.49	9	57.15	-0.51
1	48.78	-0.49	2	57.86	-0.38	4	59.20	-0.65	9	58.12	-0.30
1	49.19	-0.64	2	58.04	-0.84	4	60.75	-0.41	9	58.26	-0.24
1	49.21	8.94	2	58.87	-0.55	4	61.03	-0.74	9	58.74	-0.42
1	49.27	-0.44	2	58.93	-1.05	4	63.13	-0.39	9	60.94	-0.38
1	49.97	-0.54	2	59.04	-0.37	4	65.09	0.09	9	68.70	-1.05
1	50.45	-0.74	2	59.43	-0.41	5	51.25	-0.42	10	51.42	-0.15
1	50.60	-0.15	2	60.51	-0.32	5	54.45	-0.19	10	53.70	-0.52
1	50.73	-2.24	2	60.73	-0.86	5	55.87	-0.56	10	56.01	-0.32
1	51.29	-0.73	2	61.23	-0.75	5	57.57	-0.39	10	59.47	-1.00
1	51.49	-0.03	2	61.80	-0.29	5	58.36	-0.67	10	64.63	-0.43
1	51.58	-0.27	2	66.25	0.11	5	59.93	-0.59	11	53.35	-0.50
1	51.61	-3.11	3	50.85	-0.30	5	60.40	-0.50	11	53.49	-0.24
1	52.65	-0.15	3	51.20	-0.71	5	60.75	-0.72	11	54.17	-0.45
1	52.87	-0.26	3	51.71	-0.26	5	63.08	-2.73	11	56.04	-0.45
1	52.89	5.59	3	52.08	-0.10	5	64.60	-0.15	11	60.15	-0.63
1	53.73	4.27	3	52.79	-0.24	5	71.24	-1.54	11	69.61	-0.66
1	54.32	-0.35	3	53.04	-0.46	6	53.15	-0.23	12	54.10	-0.24
1	54.47	-0.23	3	53.36	-0.40	6	53.31	-0.16	12	57.27	0.01
1	54.60	-0.79	3	53.79	0.10	6	54.17	-0.53	12	60.54	0.10
1	55.03	-0.83	3	53.86	-0.36	6	54.91	-0.49	12	70.10	-0.66
1	55.25	-0.23	3	53.99	-1.04	6	55.11	-0.26	13	53.58	-0.30
1	55.37	-0.29	3	54.15	-0.91	6	55.28	-0.81	13	56.28	-0.50
1	56.01	-0.43	3	54.83	-0.48	6	55.31	-0.13	14	57.66	-0.06
1	56.17	-0.34	3	55.03	-0.37	6	56.05	-0.98	14	66.69	-0.27
1	56.43	0.36	3	55.06	-1.96	6	56.38	-0.38	15	65.35	-0.17
1	56.57	0.06	3	55.25	-0.44	6	57.89	-0.39	15	67.31	-0.26
1	56.76	-0.47	3	55.71	-0.30	6	58.68	-0.34	16	61.64	-0.14
1	57.05	-0.39	3	55.98	-0.37	6	59.11	-1.03	16	67.35	-0.34
1	57.07	-0.19	3	56.77	-0.44	6	59.27	-1.19	17	67.98	-0.20
1	57.09	-0.30	3	56.83	-0.26	6	62.22	-0.53	18	58.84	-0.24
1	57.74	-0.47	3	57.16	-2.90	6	62.23	0.08	20	68.66	-0.33
1	59.76	-0.31	3	57.44	-0.31	7	52.05	-0.28	21	64.10	-0.11
1	67.48	-0.07	3	57.50	-0.90	7	53.87	-0.64	22	65.56	-0.18
2	49.79	-0.38	3	57.71	-0.89	7	54.10	-0.26	23	61.15	-0.51
2	50.08	-0.77	3	58.13	-0.22	7	54.22	-0.30	23	66.59	-0.25
2	50.75	-0.48	3	58.42	-0.26	7	54.77	-0.40	28	64.78	-0.26
2	51.38	-0.58	3	58.46	-0.19	7	55.23	-0.37	29	68.41	-0.11
2	51.82	-0.11	3	59.62	-0.58	7	55.71	-0.51	30	71.04	-0.40
2	51.85	-0.59	3	60.51	-0.39	7	56.79	-0.26	31	64.66	-0.21
2	52.53	-0.26	3	60.97	-1.12	7	58.14	-1.77	33	58.77	0.02
2	52.73	-0.13	3	61.29	-0.31	7	58.53	-0.32	41	64.12	-0.19
2	52.83	-0.21	3	62.47	0.04	7	60.81	-0.31	54	63.08	0.04
2	52.90	-0.48	3	62.73	-0.63	7	64.39	-0.39	57	68.06	-0.10
2	53.56	-0.21	3	63.14	-0.35	7	64.51	-0.48	58	69.63	-0.19
2	53.59	-2.13	3	65.39	-0.84	7	64.88	-0.34	61	65.20	-0.06
2	53.91	-0.52	4	50.93	-0.26	7	66.38	-0.81	69	67.52	-0.14
2	53.95	-2.64	4	52.90	-0.74	7	67.70	-0.41			
2	55.01	-0.47	4	53.01	-0.59	8	51.01	-0.21			

A.4.2 Repeated Freeway Experiment Rich Open Loop Events

Duration	Speed	Accel	Duration	Speed	Accel	Duration	Speed	Accel
(sec)	mph	mph/s	(sec)	mph	mph/s	(sec)	mph	mph/s
1	33.63	1.71	2	52.47	0.60	3	31.96	2.01
1	37.63	1.75	2	52.98	2.84	3	32.70	3.13
1	43.61	2.77	2	54.86	1.49	3	33.26	3.13
1	54.40	1.05	2	55.37	2.12	3	50.21	1.27
1	54.73	0.59	2	55.56	0.31	3	61.27	1.23
1	61.25	0.81	2	56.46	2.50	3	61.73	1.30
1	63.24	1.12	2	57.84	0.37	4	43.20	3.01
2	28.58	2.75	2	58.11	1.26	4	61.18	0.74
2	29.51	2.96	2	58.34	0.80	5	46.36	1.07
2	37.75	1.62	2	60.50	1.23	5	60.14	1.40
2	48.91	1.75	2	60.51	1.35	6	26.15	2.92
2	52.18	1.17	2	61.06	1.20			

A.4.3 Conservative Driving Experiments Lean Open Loop Events

Duration (sec)	Speed mph	Accel mph/s	Duration (sec)	Speed mph	Accel mph/s	Duration (sec)	Speed mph	Accel mph/s	Duration (sec)	Speed mph	Accel mph/s
1	42.36	-1.77	1	54.89	-0.16	3	51.07	-0.77	6	53.20	-0.26
1	42.94	-0.93	1	56.23	-0.80	3	51.33	-0.80	6	55.10	-0.91
1	43.22	-1.48	1	56.60	-0.73	3	51.81	-0.94	6	59.32	-0.88
1	43.93	-1.81	1	56.72	-0.83	3	52.37	-0.81	6	59.94	-0.01
1	44.27	-2.92	1	57.66	-0.44	3	52.38	-1.54	7	51.90	-0.41
1	44.43	-2.50	1	58.44	-0.97	3	52.50	-1.00	7	52.32	-0.51
1	44.86	-0.71	1	58.66	-0.10	3	52.75	-1.51	7	53.19	-0.57
1	45.40	-1.44	1	59.86	-0.60	3	53.00	-1.41	7	54.33	-0.62
1	45.64	-1.33	1	59.89	-0.78	3	53.46	-0.78	7	54.47	-0.10
1	45.79	-1.04	2	49.44	-0.86	3	53.76	-0.91	7	57.87	-0.13
1	47.02	-1.21	2	49.76	-0.64	3	54.16	-0.09	7	59.79	0.03
1	47.73	-0.80	2	50.03	-0.60	3	55.83	-0.81	7	60.08	-1.64
1	47.82	-1.12	2	50.20	-0.68	3	57.17	-0.95	7	60.97	-0.80
1	47.86	-2.92	2	50.26	-0.78	3	57.62	-0.47	7	61.71	-0.43
1	48.24	-0.69	2	50.29	-0.62	3	57.88	-0.50	8	55.46	-0.65
1	48.44	-0.31	2	50.79	-0.94	3	58.38	-1.01	8	56.75	-0.47
1	48.87	-1.78	2	50.92	-2.20	3	58.54	-0.35	9	56.72	-0.67
1	49.03	-0.90	2	51.89	-0.64	3	58.84	-0.25	9	57.26	-0.86
1	49.08	-1.29	2	52.91	-0.67	3	59.23	-1.51	9	57.78	-0.54
1	49.47	-0.54	2	52.92	-2.21	3	59.39	-0.81	9	60.92	-0.36
1	50.05	-1.33	2	53.12	-0.52	3	59.84	-0.50	9	61.45	-1.41
1	50.09	-1.46	2	53.21	-2.42	3	60.17	-0.69	10	65.07	-1.75
1	50.70	-2.41	2	53.72	-3.62	3	62.30	-0.44	10	65.44	-0.08
1	50.86	-1.08	2	54.22	-0.85	4	53.35	-1.03	11	58.64	-0.63
1	50.89	-0.82	2	54.79	-0.65	4	57.09	-2.04	11	59.39	-0.76
1	50.90	-0.82	2	56.51	-3.50	4	58.62	-0.80	11	60.92	-0.37
1	51.43	-0.72	2	57.87	-0.90	4	61.60	-0.33	12	65.97	-0.15
1	51.83	0.42	2	57.88	-0.05	4	66.31	-0.54	13	62.69	-1.05
1	52.11	-0.89	2	58.72	-0.88	5	56.26	-0.99	14	58.21	-0.17
1	52.72	-0.93	2	60.29	-1.00	5	57.00	-0.49	17	55.15	-0.06
1	53.12	-0.52	2	62.19	-0.23	5	57.77	-0.25	17	64.77	-0.24
1	53.26	-0.94	2	63.53	-0.85	5	58.64	-0.45	17	67.45	-0.32
1	53.77	-0.70	2	66.23	-0.93	5	60.04	-0.23	21	61.69	-0.64
1	53.96	-0.28	3	50.84	-0.84	5	60.93	-0.48	26	68.85	-0.22

A.4.4 Conservative Driving Experiments Rich Open Loop Events

Duration (sec)	Speed mph	Acceleration mph/s
1	12.35	4.77
1	45.19	0.71
2	36.74	3.43
2	54.24	1.46
4	23.07	3.56

A.4.5 Aggressive Driving Experiments Lean Open Loop Events

Duration (sec)	Speed mph	Accel mph/s	Duration (sec)	Speed mph	Accel mph/s	Duration (sec)	Speed mph	Accel mph/s
1	2.86	3.10	1	56.76	-0.91	2	62.33	-0.51
1	42.73	-2.21	1	59.88	-0.22	2	62.47	-1.03
1	43.80	-4.56	1	61.33	-0.42	2	65.96	-0.75
1	44.79	-0.53	1	61.34	-0.42	3	51.93	-1.19
1	45.49	-1.49	1	63.45	-1.63	3	52.15	-0.80
1	45.76	-0.86	1	63.46	-1.02	3	53.31	-1.34
1	46.35	-0.62	1	67.26	-1.07	3	53.48	-2.09
1	46.82	-2.21	2	49.90	-1.81	3	54.30	-1.69
1	47.11	-1.75	2	50.40	-0.88	3	54.68	-0.16
1	48.02	-1.20	2	50.51	-0.76	3	54.80	-2.19
1	48.73	-1.16	2	50.66	-0.98	3	55.39	-2.77
1	48.88	-0.68	2	50.92	-0.98	4	54.38	-1.27
1	48.89	-0.97	2	52.35	-3.38	4	54.82	-1.67
1	49.05	-0.92	2	52.94	-1.32	4	62.05	-0.90
1	49.16	-1.04	2	54.79	-0.38	5	59.79	-1.10
1	49.57	-1.31	2	58.28	-0.59	5	59.88	-1.77
1	49.61	-3.12	2	58.96	-1.60	5	61.28	-0.33
1	51.17	-2.39	2	60.05	-1.48	8	61.45	-0.82
1	51.29	-3.72	2	60.28	-0.23	11	63.43	-1.04
1	51.72	-2.67	2	60.40	-0.52	12	67.35	-0.43
1	51.88	-3.27	2	61.91	-0.63	19	58.54	-0.06

A.4.6 Aggressive Driving Experiments Rich Open Loop Events

Duration (sec)	Speed mph	Accel mph/s	Duration (sec)	Speed mph	Accel mph/s	Duration (sec)	Speed mph	Accel mph/s
1	1.40	7.99	1	36.12	2.63	2	27.71	3.51
1	5.39	8.35	1	36.25	2.90	2	31.51	2.45
1	7.96	7.46	1	36.26	3.89	2	33.12	1.54
1	8.11	7.53	1	37.75	0.64	2	36.20	2.34
1	9.16	7.01	1	38.13	3.46	2	36.21	3.83
1	9.56	6.91	1	38.74	1.97	2	38.53	3.79
1	9.68	7.36	1	39.28	0.30	2	39.63	3.52
1	9.73	7.61	1	40.10	1.64	2	41.70	2.39
1	10.32	6.47	1	40.74	2.23	2	41.97	2.09
1	10.43	6.39	1	41.77	1.10	2	46.87	2.32
1	10.88	7.05	1	42.10	2.65	2	47.47	1.84
1	11.10	6.54	1	43.43	0.76	2	48.04	1.50
1	11.21	6.45	1	43.73	1.99	2	49.42	1.08
1	12.32	6.35	1	44.33	1.56	2	50.62	2.21
1	12.64	6.60	1	45.37	2.09	2	53.92	2.09
1	14.15	6.12	1	46.50	1.09	2	55.02	1.85
1	16.30	6.38	1	50.09	2.24	2	58.56	1.48
1	16.74	2.69	1	50.34	1.63	2	60.01	1.04
1	16.84	5.04	1	50.65	-0.35	2	61.27	2.34
1	17.13	5.99	1	53.07	1.26	2	64.25	1.51
1	19.45	3.96	1	55.93	1.71	3	0.00	6.47
1	21.97	5.63	1	57.95	1.37	3	7.72	6.32
1	22.71	4.21	1	58.02	0.09	3	13.70	3.73
1	22.85	1.57	1	59.31	1.77	3	14.30	4.32
1	23.18	2.19	1	60.11	1.33	3	16.37	4.28
1	23.22	3.73	1	60.80	1.90	3	21.72	3.34
1	23.85	0.71	1	60.98	1.55	3	22.70	3.98
1	23.90	4.16	1	62.54	1.40	3	26.90	3.91
1	24.61	1.80	1	62.63	0.60	3	29.44	3.16
1	24.90	4.06	1	63.40	0.93	3	34.35	3.86
1	28.58	3.48	1	64.75	0.86	3	36.12	2.45
1	30.65	4.88	1	64.78	0.86	3	38.29	2.91
1	31.83	2.81	1	66.10	0.56	3	44.89	2.20
1	32.11	2.17	1	73.71	0.90	3	49.41	2.89
1	32.32	2.30	2	3.78	7.69	3	49.98	1.48
1	33.21	1.79	2	3.79	8.32	4	20.86	4.18
1	33.28	2.95	2	4.63	7.29	4	35.24	3.34
1	33.41	3.53	2	4.65	7.35	4	47.12	2.17
1	33.66	2.50	2	7.11	6.30	4	56.99	1.88
1	33.90	1.51	2	7.81	6.21	5	7.48	4.46
1	34.03	3.81	2	7.82	6.86	5	7.69	4.76
1	34.19	2.44	2	12.21	4.71	5	20.88	3.90
1	34.55	2.09	2	14.17	5.08	5	23.45	3.26
1	34.86	1.88	2	14.24	4.32	5	28.03	3.22
1	34.88	3.10	2	16.40	3.96	5	53.52	1.21
1	35.20	1.63	2	16.72	3.49	6	11.33	3.86
1	35.56	3.79	2	21.37	3.50	6	25.60	3.85
1	35.68	1.88	2	22.16	3.75	8	36.50	2.26
1	35.96	3.27	2	25.17	3.93			
1	36.06	2.65	2	25.74	3.71			

A.5 UCLA Developed Dynamomometer Driving Schedules

A.5.1 UCLA Freeway Dynamometer Driving Schedule

Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity
1	0.0	61	57.3	121	65.7	181	61.9	241	40.4	301	57.7	361	55.8
2	0.0	62	57.5	122	65.5	182	61.8	242	42.0	302	57.2	362	55.6
3	0.0	63	57.6	123	65.1	183	61.5	243	43.3	303	56.9	363	55.7
4	2.0	64	57.7	124	65.0	184	61.1	244	44.5	304	56.9	364	55.9
5	6.5	65	57.8	125	65.1	185	60.9	245	45.5	305	57.1	365	55.9
6	10.5	66	57.8	126	65.3	186	61.0	246	46.5	306	57.3	366	56.1
7	13.8	67	57.9	127	65.6	187	61.0	247	47.1	307	57.7	367	56.0
8	16.1	68	58.1	128	66.0	188	61.0	248	47.7	308	58.1	368	55.8
9	18.4	69	58.2	129	66.3	189	61.1	249	48.3	309	58.5	369	55.2
10	20.4	70	58.4	130	66.1	190	61.3	250	48.9	310	58.8	370	54.5
11	22.5	71	58.7	131	65.8	191	61.6	251	49.3	311	59.3	371	53.8
12	24.5	72	58.9	132	65.1	192	61.7	252	49.5	312	59.6	372	52.6
13	26.3	73	59.1	133	64.5	193	61.5	253	49.4	313	59.8	373	48.9
14	27.7	74	59.4	134	63.8	194	61.5	254	49.3	314	59.6	374	45.2
15	28.8	75	59.7	135	63.2	195	61.9	255	49.2	315	59.4	375	43.5
16	29.1	76	60.0	136	62.7	196	61.9	256	49.6	316	59.3	376	43.2
17	29.0	77	60.2	137	62.0	197	61.7	257	49.9	317	59.3	377	42.4
18	28.6	78	60.3	138	61.1	198	61.6	258	50.3	318	59.0	378	40.6
19	27.7	79	60.7	139	60.4	199	61.5	259	50.7	319	58.7	379	35.3
20	26.0	80	61.1	140	60.1	200	61.1	260	51.3	320	58.5	380	31.2
21	23.3	81	61.4	141	60.3	201	60.9	261	52.0	321	58.5	381	28.1
22	19.6	82	61.7	142	59.9	202	60.9	262	52.4	322	58.6	382	26.5
23	18.4	83	61.9	143	59.7	203	61.5	263	52.4	323	58.7	383	26.4
24	19.1	84	62.2	144	60.0	204	62.2	264	52.5	324	58.8	384	26.2
25	20.9	85	62.8	145	60.7	205	62.6	265	52.3	325	59.3	385	26.0
26	23.8	86	63.4	146	61.5	206	63.2	266	52.2	326	60.0	386	25.7
27	27.4	87	63.9	147	61.8	207	63.6	267	52.2	327	60.9	387	24.2
28	30.4	88	64.3	148	61.8	208	63.5	268	52.5	328	62.0	388	22.1
29	33.4	89	64.7	149	61.3	209	63.0	269	53.0	329	63.6	389	20.3
30	36.1	90	65.0	150	60.7	210	62.5	270	53.5	330	65.3	390	19.3
31	39.0	91	65.2	151	59.8	211	61.7	271	54.1	331	66.8	391	19.2
32	41.3	92	65.1	152	59.0	212	61.0	272	54.6	332	66.8	392	19.0
33	43.5	93	64.9	153	58.2	213	60.2	273	54.8	333	66.0	393	18.9
34	44.9	94	64.7	154	57.6	214	59.5	274	54.8	334	65.0	394	18.3
35	46.0	95	64.6	155	57.3	215	57.8	275	56.5	335	64.1	395	16.9
36	47.1	96	64.6	156	57.4	216	53.7	276	56.6	336	63.4	396	14.6
37	48.2	97	64.2	157	57.6	217	50.2	277	56.9	337	62.5	397	11.9
38	49.0	98	63.4	158	57.8	218	46.5	278	57.1	338	61.7	398	9.7
39	49.9	99	62.6	159	57.7	219	44.9	279	57.2	339	61.0	399	9.2
40	50.8	100	61.9	160	57.2	220	44.4	280	57.3	340	60.3	400	9.4
41	51.8	101	61.2	161	56.8	221	44.2	281	57.6	341	59.5	401	10.1
42	52.7	102	60.5	162	57.0	222	43.6	282	58.1	342	58.7	402	11.4
43	53.5	103	60.3	163	57.6	223	41.5	283	58.3	343	57.9	403	12.9
44	54.2	104	60.1	164	58.0	224	37.9	284	58.6	344	57.0	404	14.4
45	54.9	105	60.1	165	58.4	225	36.7	285	58.5	345	56.2	405	16.3
46	55.6	106	60.0	166	58.6	226	36.8	286	58.3	346	55.4	406	17.9
47	56.5	107	60.1	167	58.8	227	36.6	287	58.4	347	55.3	407	19.4
48	57.3	108	60.0	168	58.9	228	36.8	288	58.5	348	56.2	408	21.1
49	58.1	109	60.4	169	59.1	229	36.6	289	58.5	349	56.9	409	23.0
50	58.9	110	61.3	170	59.2	230	36.2	290	58.3	350	57.3	410	25.2
51	59.6	111	62.0	171	59.2	231	35.2	291	58.1	351	57.3	411	27.4
52	60.0	112	62.2	172	59.5	232	33.9	292	57.9	352	57.1	412	28.4
53	59.8	113	62.0	173	59.7	233	32.8	293	57.5	353	56.7	413	28.2
54	59.3	114	61.7	174	60.1	234	32.6	294	57.0	354	56.3	414	27.9
55	58.6	115	62.2	175	60.5	235	32.7	295	56.8	355	56.0	415	27.6
56	58.1	116	63.1	176	60.8	236	32.9	296	56.8	356	55.9	416	27.3
57	57.3	117	64.0	177	61.0	237	33.9	297	57.1	357	56.1	417	27.0
58	56.9	118	65.0	178	61.4	238	35.2	298	57.4	358	56.1	418	26.8
59	57.0	119	65.7	179	61.8	239	36.8	299	57.7	359	56.0	419	26.4
60	57.1	120	65.8	180	62.0	240	38.8	300	57.8	360	56.0	420	26.1

Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity
421	25.8	481	26.4	541	7.1	601	5.8	661	25.1	721	40.1	781	13.4
422	24.1	482	26.2	542	7.3	602	4.1	662	25.3	722	39.9	782	13.8
423	21.7	483	25.9	543	6.4	603	3.1	663	25.7	723	39.4	783	14.6
424	19.7	484	25.7	544	2.0	604	1.1	664	26.1	724	38.9	784	15.1
425	19.1	485	25.9	545	0.0	605	0.0	665	26.1	725	39.3	785	15.2
426	19.3	486	26.4	546	0.0	606	0.0	666	25.8	726	39.3	786	14.8
427	19.6	487	27.0	547	0.0	607	0.0	667	25.4	727	39.8	787	13.6
428	19.7	488	27.8	548	0.0	608	0.0	668	25.1	728	40.7	788	11.8
429	19.3	489	28.0	549	0.0	609	0.0	669	24.8	729	41.2	789	10.8
430	19.2	490	28.2	550	0.0	610	0.0	670	24.5	730	42.1	790	12.1
431	19.5	491	28.8	551	0.0	611	0.0	671	24.3	731	42.8	791	13.7
432	19.9	492	29.7	552	0.3	612	0.0	672	24.3	732	43.6	792	14.6
433	20.6	493	29.7	553	2.9	613	0.0	673	25.1	733	44.8	793	15.2
434	21.4	494	29.4	554	3.9	614	0.0	674	26.4	734	45.9	794	15.8
435	22.5	495	29.4	555	5.5	615	1.7	675	27.5	735	46.6	795	16.1
436	24.0	496	29.2	556	6.8	616	3.0	676	28.5	736	46.5	796	15.9
437	25.2	497	29.0	557	8.0	617	3.8	677	29.1	737	46.4	797	16.2
438	25.6	498	28.8	558	8.9	618	4.6	678	29.6	738	46.3	798	16.2
439	25.9	499	28.7	559	10.0	619	5.7	679	29.3	739	46.2	799	16.3
440	26.2	500	28.9	560	10.7	620	7.0	680	29.0	740	46.3	800	16.3
441	26.4	501	28.7	561	11.1	621	8.6	681	28.4	741	47.3	801	16.3
442	26.6	502	28.4	562	11.3	622	10.3	682	26.1	742	48.2	802	16.4
443	26.9	503	28.2	563	11.4	623	11.7	683	23.8	743	49.0	803	16.4
444	27.2	504	28.0	564	11.5	624	13.3	684	23.3	744	49.4	804	16.3
445	27.4	505	27.7	565	11.5	625	14.2	685	23.0	745	49.3	805	16.2
446	27.5	506	27.4	566	11.4	626	14.6	686	22.8	746	49.3	806	16.3
447	27.8	507	25.2	567	10.5	627	14.8	687	22.9	747	48.9	807	16.4
448	28.0	508	21.3	568	8.8	628	14.2	688	24.2	748	48.4	808	17.0
449	28.2	509	18.7	569	6.7	629	12.8	689	25.4	749	47.6	809	17.5
450	28.2	510	16.7	570	5.3	630	12.0	690	26.3	750	47.3	810	17.9
451	28.3	511	13.9	571	4.1	631	10.9	691	27.4	751	47.6	811	18.3
452	28.3	512	11.8	572	2.9	632	9.1	692	28.1	752	47.4	812	18.8
453	28.7	513	11.7	573	0.9	633	7.7	693	28.7	753	46.8	813	19.5
454	29.5	514	11.8	574	0.0	634	6.4	694	29.6	754	46.0	814	20.3
455	30.1	515	11.9	575	0.0	635	5.3	695	30.0	755	45.2	815	21.1
456	30.4	516	12.1	576	0.0	636	4.9	696	30.6	756	44.2	816	22.3
457	30.9	517	12.3	577	0.0	637	4.4	697	31.2	757	43.7	817	23.4
458	31.2	518	12.2	578	1.4	638	4.0	698	32.2	758	43.6	818	23.8
459	31.5	519	12.3	579	3.0	639	3.8	699	32.9	759	44.0	819	24.1
460	32.0	520	12.4	580	3.7	640	3.5	700	33.0	760	44.3	820	24.0
461	32.0	521	12.3	581	4.5	641	3.8	701	33.6	761	44.0	821	24.0
462	31.9	522	12.3	582	5.4	642	4.3	702	34.0	762	43.2	822	24.4
463	32.1	523	12.5	583	6.3	643	4.6	703	34.3	763	42.5	823	25.2
464	32.8	524	12.6	584	7.0	644	5.6	704	34.2	764	40.8	824	26.4
465	33.4	525	12.9	585	7.7	645	7.4	705	34.2	765	38.2	825	27.5
466	33.5	526	12.9	586	8.2	646	9.4	706	33.9	766	35.1	826	28.0
467	33.3	527	12.8	587	8.9	647	11.9	707	33.9	767	32.1	827	28.2
468	32.8	528	12.9	588	9.7	648	14.0	708	34.7	768	29.2	828	28.0
469	32.5	529	12.8	589	10.2	649	15.7	709	35.5	769	27.1	829	27.7
470	32.0	530	12.0	590	10.6	650	17.6	710	35.6	770	26.6	830	27.6
471	30.3	531	10.8	591	10.9	651	18.8	711	35.9	771	26.1	831	27.4
472	28.1	532	9.0	592	11.2	652	19.1	712	36.2	772	26.0	832	27.2
473	25.6	533	7.4	593	11.2	653	19.2	713	36.9	773	25.4	833	27.0
474	25.1	534	6.5	594	11.4	654	19.3	714	37.5	774	23.7	834	27.1
475	25.3	535	6.5	595	11.5	655	19.4	715	38.3	775	20.0	835	28.2
476	26.2	536	6.8	596	10.8	656	20.0	716	38.9	776	17.2	836	29.3
477	27.0	537	6.7	597	8.4	657	21.0	717	39.6	777	16.5	837	29.8
478	26.9	538	6.6	598	7.2	658	22.2	718	39.9	778	15.9	838	29.7
479	26.8	539	6.7	599	7.3	659	23.4	719	40.0	779	14.6	839	29.7
480	26.6	540	6.9	600	7.0	660	24.5	720	40.0	780	13.4	840	30.2

UCLA Freeway Dynamometer Driving Schedule (continued)

Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity
841	30.9	901	43.4	961	52.5	1021	12.6	1081	14.3	1141	15.5	1201	8.8
842	30.7	902	44.1	962	52.6	1022	12.7	1082	13.5	1142	17.6	1202	8.8
843	30.6	903	44.3	963	52.8	1023	13.2	1083	12.9	1143	19.6	1203	8.7
844	30.2	904	44.1	964	52.9	1024	13.7	1084	11.9	1144	21.6	1204	9.1
845	30.1	905	44.4	965	52.7	1025	14.3	1085	9.8	1145	23.4	1205	10.5
846	29.8	906	45.1	966	51.8	1026	14.7	1086	8.5	1146	25.2	1206	13.1
847	29.5	907	45.7	967	50.8	1027	14.8	1087	8.2	1147	26.7	1207	15.4
848	29.3	908	46.2	968	49.6	1028	15.2	1088	8.4	1148	28.4	1208	16.2
849	29.0	909	46.8	969	48.5	1029	15.2	1089	9.8	1149	29.7	1209	17.1
850	28.8	910	47.2	970	47.6	1030	15.6	1090	11.1	1150	30.8	1210	17.4
851	28.7	911	47.1	971	47.4	1031	15.6	1091	12.0	1151	31.0	1211	17.1
852	28.4	912	47.1	972	47.5	1032	15.6	1092	13.6	1152	30.8	1212	14.5
853	27.4	913	47.2	973	47.8	1033	15.9	1093	14.0	1153	30.3	1213	11.2
854	25.5	914	47.5	974	47.7	1034	16.0	1094	15.2	1154	28.9	1214	9.6
855	24.4	915	47.9	975	47.3	1035	16.1	1095	15.5	1155	27.8	1215	8.9
856	24.2	916	48.2	976	47.1	1036	15.9	1096	15.3	1156	27.6	1216	9.1
857	24.2	917	48.6	977	46.8	1037	16.1	1097	13.6	1157	27.2	1217	9.4
858	24.5	918	48.9	978	46.5	1038	16.2	1098	11.5	1158	27.3	1218	10.1
859	25.0	919	48.8	979	46.5	1039	16.3	1099	10.5	1159	27.3	1219	11.4
860	26.1	920	48.9	980	46.5	1040	15.1	1100	8.3	1160	27.3	1220	12.2
861	27.1	921	49.2	981	46.1	1041	10.9	1101	7.1	1161	28.2	1221	13.5
862	28.8	922	49.7	982	46.2	1042	7.2	1102	6.8	1162	28.8	1222	15.9
863	30.7	923	50.1	983	45.8	1043	5.2	1103	6.5	1163	29.0	1223	17.8
864	32.6	924	50.6	984	45.0	1044	4.4	1104	6.6	1164	28.9	1224	19.9
865	33.2	925	51.1	985	43.8	1045	3.2	1105	6.6	1165	27.8	1225	21.5
866	33.6	926	51.4	986	40.4	1046	3.5	1106	6.7	1166	24.1	1226	23.3
867	33.5	927	51.8	987	36.8	1047	4.2	1107	6.7	1167	19.7	1227	25.3
868	34.3	928	51.6	988	33.1	1048	4.9	1108	6.5	1168	16.9	1228	27.5
869	35.0	929	51.3	989	31.2	1049	6.0	1109	5.2	1169	16.2	1229	29.0
870	36.1	930	51.5	990	30.2	1050	7.5	1110	4.0	1170	16.1	1230	30.5
871	36.7	931	51.9	991	29.2	1051	9.1	1111	3.8	1171	16.5	1231	32.4
872	36.3	932	52.1	992	28.4	1052	10.4	1112	2.7	1172	17.2	1232	34.1
873	36.4	933	51.8	993	27.5	1053	10.9	1113	0.0	1173	18.7	1233	35.8
874	36.3	934	51.5	994	26.5	1054	10.8	1114	0.0	1174	17.0	1234	37.6
875	36.1	935	51.5	995	25.7	1055	10.8	1115	0.0	1175	15.3	1235	38.9
876	35.8	936	51.5	996	24.6	1056	10.8	1116	0.0	1176	15.0	1236	39.3
877	35.4	937	51.6	997	22.3	1057	11.6	1117	0.0	1177	15.2	1237	39.3
878	34.9	938	51.9	998	19.1	1058	12.9	1118	0.0	1178	16.8	1238	39.8
879	34.6	939	52.4	999	16.5	1059	13.1	1119	0.0	1179	18.7	1239	39.4
880	33.5	940	53.0	1000	15.5	1060	13.1	1120	0.0	1180	20.8	1240	39.7
881	33.0	941	53.8	1001	15.1	1061	12.8	1121	0.0	1181	23.3	1241	39.1
882	32.6	942	54.4	1002	15.5	1062	10.3	1122	0.0	1182	25.6	1242	38.8
883	32.2	943	54.7	1003	16.2	1063	5.7	1123	0.0	1183	27.8	1243	38.6
884	32.0	944	54.4	1004	17.1	1064	3.0	1124	0.0	1184	30.1	1244	38.7
885	32.4	945	53.9	1005	18.2	1065	2.9	1125	0.0	1185	32.5	1245	38.5
886	32.4	946	54.2	1006	19.3	1066	3.3	1126	0.0	1186	34.8	1246	38.8
887	33.2	947	55.3	1007	20.3	1067	4.0	1127	1.7	1187	36.3	1247	39.4
888	34.5	948	57.2	1008	21.8	1068	5.2	1128	3.1	1188	36.6	1248	40.4
889	35.9	949	58.2	1009	19.6	1069	6.9	1129	4.3	1189	36.3	1249	41.5
890	37.4	950	58.0	1010	19.2	1070	9.1	1130	5.2	1190	35.6	1250	42.6
891	39.2	951	57.3	1011	17.2	1071	11.4	1131	5.7	1191	33.4	1251	43.3
892	41.4	952	56.4	1012	14.6	1072	13.1	1132	5.9	1192	29.1	1252	44.1
893	42.4	953	56.0	1013	12.0	1073	14.9	1133	6.1	1193	27.3	1253	45.0
894	42.8	954	55.7	1014	11.3	1074	16.3	1134	6.4	1194	27.0	1254	45.7
895	43.1	955	55.4	1015	11.5	1075	17.3	1135	6.6	1195	24.6	1255	47.7
896	43.2	956	55.2	1016	11.9	1076	17.5	1136	7.0	1196	17.8	1256	49.7
897	43.3	957	55.2	1017	12.3	1077	17.3	1137	7.5	1197	11.9	1257	51.6
898	43.7	958	54.7	1018	12.5	1078	17.1	1138	9.1	1198	9.2	1258	53.3
899	43.9	959	53.7	1019	12.7	1079	16.7	1139	11.2	1199	8.8	1259	54.2
900	43.6	960	52.7	1020	12.5	1080	15.2	1140	13.2	1200	8.7	1260	54.3

UCLA Freeway Dynamometer Driving Schedule (continued)

Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity
1261	54.3	1281	59.2	1301	57.4	1321	54.1	1341	27.0	1361	11.3	1381	16.5
1262	54.2	1282	58.9	1302	56.5	1322	54.7	1342	21.2	1362	11.0	1382	17.1
1263	54.7	1283	58.9	1303	55.7	1323	54.7	1343	18.9	1363	10.9	1383	17.2
1264	55.4	1284	59.3	1304	55.2	1324	54.9	1344	18.5	1364	10.8	1384	16.9
1265	55.6	1285	59.7	1305	55.3	1325	54.7	1345	18.9	1365	10.6	1385	16.4
1266	56.1	1286	59.8	1306	55.6	1326	54.3	1346	20.2	1366	10.6	1386	13.8
1267	56.9	1287	59.8	1307	56.0	1327	54.3	1347	21.2	1367	10.6	1387	10.7
1268	57.4	1288	59.4	1308	56.6	1328	54.8	1348	21.6	1368	10.6	1388	8.1
1269	57.2	1289	58.8	1309	57.1	1329	55.5	1349	21.9	1369	10.5	1389	5.1
1270	56.8	1290	58.1	1310	57.5	1330	55.4	1350	22.2	1370	11.0	1390	2.1
1271	56.6	1291	57.3	1311	57.9	1331	54.7	1351	22.0	1371	11.6	1391	0.0
1272	56.2	1292	56.5	1312	58.0	1332	52.4	1352	21.8	1372	12.3	1392	0.0
1273	55.4	1293	56.2	1313	57.5	1333	48.4	1353	21.6	1373	13.7	1393	0.0
1274	55.3	1294	56.3	1314	56.8	1334	44.0	1354	21.4	1374	14.0	1394	0.0
1275	56.0	1295	56.7	1315	56.4	1335	40.8	1355	21.0	1375	14.9	1395	0.0
1276	56.6	1296	57.3	1316	56.5	1336	36.9	1356	19.8	1376	15.4	1396	0.0
1277	57.1	1297	58.1	1317	56.2	1337	34.0	1357	17.4	1377	15.8	1397	0.0
1278	57.6	1298	58.6	1318	55.5	1338	33.0	1358	15.0	1378	15.9	1398	0.0
1279	58.1	1299	58.7	1319	54.8	1339	32.8	1359	12.4	1379	16.0	1399	0.0
1280	58.7	1300	58.1	1320	54.1	1340	31.9	1360	11.3	1380	16.0	1400	0.0

A.5.2 UCLA Urban Dynamometer Driving Schedule

Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity
1	0.0	61	41.2	121	44.1	181	39.8	241	0.0	301	24.2	361	31.6
2	0.0	62	40.8	122	43.6	182	40.7	242	0.0	302	25.0	362	31.9
3	0.0	63	39.4	123	43.3	183	41.4	243	0.0	303	25.8	363	32.0
4	0.0	64	38.4	124	42.9	184	41.9	244	0.9	304	26.4	364	32.9
5	0.0	65	38.4	125	42.0	185	42.6	245	4.6	305	27.2	365	33.0
6	0.0	66	37.8	126	40.8	186	43.3	246	8.0	306	27.7	366	32.8
7	0.0	67	38.1	127	37.5	187	43.9	247	11.3	307	27.6	367	31.6
8	0.0	68	38.2	128	33.9	188	44.8	248	14.3	308	27.7	368	30.0
9	0.0	69	38.2	129	30.1	189	45.8	249	16.5	309	27.4	369	28.5
10	0.0	70	38.7	130	26.3	190	46.4	250	18.7	310	27.4	370	27.1
11	2.5	71	38.3	131	22.2	191	46.5	251	20.4	311	27.5	371	25.5
12	8.8	72	37.7	132	16.8	192	46.1	252	21.0	312	27.6	372	23.2
13	12.3	73	37.7	133	12.2	193	45.6	253	21.4	313	28.2	373	21.0
14	14.8	74	37.4	134	7.9	194	44.7	254	21.8	314	29.2	374	16.5
15	17.1	75	36.6	135	4.0	195	43.8	255	21.8	315	29.6	375	12.1
16	19.3	76	36.4	136	0.9	196	43.0	256	21.3	316	29.5	376	8.0
17	21.9	77	36.5	137	0.0	197	43.0	257	20.9	317	29.7	377	4.5
18	24.4	78	36.1	138	2.6	198	43.0	258	20.8	318	29.6	378	4.1
19	26.4	79	35.7	139	9.5	199	43.3	259	21.0	319	29.8	379	5.0
20	27.7	80	34.5	140	15.0	200	44.2	260	21.3	320	29.4	380	6.1
21	29.0	81	32.8	141	19.9	201	45.0	261	21.5	321	29.3	381	9.5
22	30.3	82	30.8	142	24.1	202	45.8	262	21.7	322	28.8	382	13.6
23	31.1	83	29.2	143	27.4	203	46.9	263	21.8	323	28.4	383	17.2
24	32.1	84	28.3	144	29.7	204	47.9	264	21.4	324	28.4	384	20.9
25	33.0	85	25.9	145	31.9	205	48.3	265	20.8	325	28.5	385	24.1
26	34.4	86	25.1	146	34.2	206	47.8	266	19.5	326	28.8	386	26.4
27	34.6	87	26.2	147	36.4	207	47.4	267	18.7	327	28.9	387	28.7
28	35.1	88	28.0	148	38.5	208	46.9	268	18.9	328	29.1	388	30.9
29	36.5	89	29.4	149	40.3	209	46.4	269	19.1	329	29.3	389	33.2
30	37.4	90	30.1	150	41.8	210	46.5	270	19.3	330	29.7	390	35.9
31	38.3	91	29.9	151	43.3	211	47.1	271	19.4	331	31.0	391	37.9
32	38.7	92	29.1	152	44.7	212	47.7	272	18.2	332	32.1	392	38.7
33	39.1	93	26.7	153	44.8	213	48.4	273	16.6	333	32.2	393	38.6
34	39.6	94	24.7	154	44.3	214	48.9	274	15.3	334	32.7	394	38.8
35	39.9	95	24.4	155	43.8	215	49.3	275	15.4	335	32.9	395	38.6
36	40.1	96	24.4	156	42.9	216	49.3	276	15.8	336	32.5	396	38.6
37	40.1	97	24.3	157	42.2	217	49.2	277	15.7	337	31.9	397	38.2
38	40.4	98	24.3	158	39.9	218	48.9	278	14.1	338	31.1	398	37.9
39	40.8	99	24.8	159	38.1	219	48.4	279	11.7	339	30.0	399	37.7
40	41.2	100	25.3	160	36.8	220	47.8	280	9.4	340	29.5	400	37.6
41	41.8	101	25.3	161	35.9	221	46.0	281	8.0	341	29.4	401	37.2
42	42.5	102	25.0	162	33.6	222	43.0	282	6.3	342	29.5	402	37.5
43	42.6	103	23.8	163	30.2	223	38.1	283	4.2	343	29.7	403	36.8
44	42.6	104	23.2	164	28.4	224	32.4	284	2.9	344	29.8	404	36.3
45	42.2	105	22.5	165	26.4	225	27.7	285	2.9	345	29.8	405	36.4
46	42.1	106	22.5	166	24.4	226	23.8	286	2.9	346	29.9	406	36.2
47	42.1	107	22.3	167	24.0	227	20.9	287	2.9	347	29.9	407	36.9
48	41.9	108	22.3	168	24.3	228	18.3	288	2.9	348	29.7	408	37.7
49	41.4	109	23.8	169	26.0	229	14.6	289	2.9	349	29.6	409	38.2
50	41.0	110	26.8	170	27.5	230	10.5	290	2.9	350	29.7	410	38.0
51	39.7	111	30.2	171	28.0	231	6.7	291	4.5	351	30.2	411	37.7
52	39.8	112	33.7	172	28.6	232	3.0	292	8.6	352	31.1	412	37.2
53	39.2	113	36.9	173	29.5	233	0.0	293	12.0	353	32.4	413	37.3
54	38.9	114	40.0	174	31.3	234	0.0	294	14.9	354	33.0	414	37.1
55	39.0	115	42.5	175	32.9	235	0.0	295	18.1	355	33.1	415	36.5
56	39.5	116	44.7	176	33.6	236	0.0	296	20.2	356	33.3	416	36.0
57	39.8	117	45.5	177	34.4	237	0.0	297	20.5	357	32.9	417	35.6
58	40.6	118	45.3	178	35.8	238	0.0	298	21.1	358	32.0	418	35.4
59	41.1	119	45.0	179	37.3	239	0.0	299	21.5	359	31.7	419	35.4
60	41.4	120	44.4	180	38.8	240	0.0	300	22.8	360	31.6	420	35.0

UCLA Urban Dynamometer Driving Schedule (continued)

Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity
421	32.8	481	0.0	541	2.0	601	0.9	661	30.0	721	32.3	781	18.4
422	28.7	482	0.0	542	0.0	602	0.0	662	23.5	722	32.1	782	18.4
423	25.6	483	0.0	543	0.0	603	0.0	663	21.9	723	32.1	783	18.6
424	23.7	484	0.0	544	0.0	604	0.0	664	23.3	724	31.7	784	18.5
425	22.6	485	0.0	545	0.0	605	0.0	665	25.1	725	29.9	785	16.7
426	20.3	486	0.0	546	0.0	606	0.0	666	27.4	726	27.5	786	14.0
427	17.6	487	0.0	547	0.0	607	0.0	667	29.6	727	25.0	787	11.2
428	15.1	488	0.0	548	1.0	608	0.0	668	31.7	728	21.8	788	8.1
429	12.8	489	0.0	549	8.0	609	0.0	669	32.6	729	18.2	789	5.9
430	10.7	490	0.0	550	13.6	610	0.0	670	33.2	730	15.8	790	4.9
431	8.8	491	0.0	551	17.9	611	0.0	671	32.9	731	13.4	791	3.8
432	8.8	492	0.0	552	21.5	612	0.0	672	31.6	732	9.6	792	3.2
433	9.1	493	0.0	553	23.9	613	0.0	673	30.0	733	7.7	793	1.5
434	10.2	494	0.0	554	25.2	614	0.0	674	27.7	734	5.3	794	0.0
435	12.9	495	0.0	555	26.1	615	0.0	675	24.8	735	2.1	795	0.0
436	16.2	496	0.0	556	27.4	616	0.0	676	21.7	736	0.0	796	0.0
437	19.3	497	0.0	557	28.5	617	0.0	677	18.6	737	0.0	797	0.0
438	22.0	498	3.3	558	28.8	618	0.0	678	16.4	738	0.0	798	0.0
439	23.4	499	9.2	559	28.7	619	0.0	679	14.2	739	0.0	799	0.0
440	23.9	500	14.1	560	28.6	620	0.0	680	11.7	740	0.0	800	3.6
441	24.4	501	17.8	561	27.3	621	0.0	681	8.5	741	0.0	801	5.9
442	25.7	502	20.6	562	24.3	622	0.0	682	5.1	742	0.0	802	10.4
443	27.5	503	21.6	563	21.1	623	0.9	683	3.0	743	0.0	803	13.8
444	29.1	504	22.0	564	17.3	624	6.3	684	0.0	744	2.0	804	16.2
445	30.0	505	22.5	565	13.6	625	10.4	685	0.0	745	3.6	805	18.1
446	30.3	506	22.3	566	9.1	626	13.0	686	1.0	746	6.9	806	20.0
447	30.5	507	22.0	567	5.0	627	15.4	687	7.0	747	9.7	807	21.9
448	30.5	508	18.9	568	1.8	628	18.3	688	12.8	748	11.8	808	23.5
449	30.6	509	14.5	569	0.0	629	20.8	689	17.4	749	11.0	809	24.7
450	30.3	510	10.2	570	0.0	630	21.6	690	20.8	750	8.9	810	25.4
451	30.2	511	5.9	571	0.0	631	21.4	691	22.3	751	8.3	811	26.8
452	29.8	512	1.6	572	0.0	632	22.0	692	23.0	752	8.1	812	28.3
453	29.9	513	0.0	573	4.2	633	23.9	693	23.8	753	10.2	813	29.8
454	30.4	514	0.0	574	9.6	634	24.8	694	24.8	754	12.6	814	31.7
455	30.3	515	0.0	575	14.6	635	25.4	695	25.8	755	13.4	815	33.1
456	30.1	516	0.0	576	19.1	636	26.1	696	26.9	756	13.4	816	33.9
457	29.8	517	0.0	577	22.2	637	26.6	697	27.7	757	13.1	817	34.2
458	29.4	518	1.5	578	24.3	638	26.0	698	28.6	758	12.6	818	34.8
459	29.0	519	8.6	579	26.0	639	24.1	699	29.1	759	12.7	819	34.6
460	28.6	520	13.6	580	28.0	640	23.0	700	29.5	760	12.3	820	35.1
461	28.[illegible]	521	16.9	581	29.5	641	21.1	701	30.0	761	11.4	821	35.4
462	27.8	522	20.2	582	30.5	642	19.2	702	30.6	762	11.1	822	35.0
463	27.2	523	22.9	583	31.6	643	19.0	703	30.4	763	11.2	823	34.5
464	25.8	524	25.2	584	32.3	644	17.3	704	30.2	764	12.2	824	34.2
465	23.3	525	27.3	585	32.8	645	16.3	705	30.1	765	12.9	825	33.6
466	20.4	526	29.1	586	33.7	646	15.7	706	30.0	766	12.9	826	32.6
467	17.5	527	30.5	587	34.5	647	14.9	707	30.0	767	13.0	827	30.8
468	14.3	528	31.0	588	34.9	648	14.7	708	29.8	768	13.2	828	28.1
469	10.8	529	30.6	589	35.4	649	15.5	709	29.4	769	13.3	829	24.7
470	7.3	530	30.3	590	35.8	650	16.6	710	29.[illegible]	770	13.2	830	20.8
471	4.0	531	28.7	591	35.6	651	18.2	711	29.5	771	12.9	831	16.5
472	0.6	532	24.7	592	33.5	652	20.6	712	[illegible]	772	12.8	832	11.4
473	0.0	533	20.5	593	31.4	653	23.3	713	30.5	773	13.4	833	10.1
474	0.0	534	16.6	594	29.0	654	25.8	714	32.0	774	14.7	834	9.9
475	0.0	535	13.6	595	26.1	655	27.5	715	33.5	775	17.3	835	8.9
476	0.0	536	10.5	596	23.0	656	28.1	716	33.4	776	19.7	836	8.3
477	0.0	537	7.3	597	18.7	657	29.2	717	33.3	777	20.5	837	10.1
478	0.0	538	5.1	598	14.2	658	30.4	718	33.1	778	20.5	838	14.0
479	0.0	539	4.0	599	8.5	659	30.8	719	32.8	779	20.4	839	18.4
480	0.0	540	3.4	600	4.0	660	31.8	720	32.4	780	19.5	840	21.8

UCLA Urban Dynamometer Driving Schedule (continued)

Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity
841	24.4	901	15.1	961	32.4	1021	0.0	1081	0.0	1141	0.0	1201	45.2
842	26.2	902	16.0	962	33.2	1022	0.0	1082	0.0	1142	0.0	1202	46.2
843	28.2	903	18.0	963	33.5	1023	0.0	1083	0.0	1143	0.0	1203	46.1
844	29.8	904	20.2	964	33.4	1024	0.0	1084	0.0	1144	0.0	1204	45.2
845	30.7	905	22.2	965	31.9	1025	0.0	1085	0.0	1145	0.0	1205	43.8
846	31.2	906	23.6	966	29.3	1026	0.0	1086	0.0	1146	0.0	1206	42.3
847	32.8	907	23.4	967	26.4	1027	0.0	1087	0.0	1147	0.0	1207	40.9
848	34.6	908	21.3	968	23.3	1028	0.0	1088	0.0	1148	0.0	1208	39.3
849	35.9	909	20.6	969	20.0	1029	0.0	1089	0.0	1149	0.0	1209	38.6
850	36.9	910	22.1	970	17.1	1030	0.0	1090	0.0	1150	0.0	1210	37.3
851	37.6	911	24.8	971	13.5	1031	0.0	1091	0.0	1151	0.0	1211	36.0
852	38.2	912	27.8	972	9.6	1032	0.0	1092	0.0	1152	0.0	1212	35.5
853	39.3	913	30.4	973	7.1	1033	0.0	1093	0.0	1153	0.0	1213	35.7
854	39.9	914	32.3	974	4.4	1034	0.0	1094	0.0	1154	0.0	1214	36.3
855	40.0	915	32.6	975	1.7	1035	0.0	1095	0.0	1155	0.0	1215	37.5
856	40.4	916	32.8	976	0.0	1036	0.0	1096	0.0	1156	0.0	1216	38.6
857	41.5	917	33.9	977	0.0	1037	1.1	1097	0.0	1157	0.0	1217	39.4
858	41.7	918	35.1	978	0.0	1038	2.9	1098	2.9	1158	0.0	1218	40.1
859	41.1	919	34.8	979	0.0	1039	2.9	1099	3.2	1159	0.0	1219	40.5
860	41.0	920	33.5	980	0.0	1040	1.4	1100	3.7	1160	0.0	1220	40.1
861	40.1	921	30.2	981	0.0	1041	0.0	1101	3.2	1161	0.0	1221	39.4
862	39.2	922	26.9	982	0.0	1042	0.0	1102	0.6	1162	0.0	1222	36.1
863	38.2	923	22.8	983	0.0	1043	0.0	1103	0.0	1163	0.9	1223	32.4
864	37.3	924	21.9	984	0.0	1044	0.0	1104	0.0	1164	2.9	1224	28.7
865	36.8	925	23.5	985	0.0	1045	0.0	1105	0.0	1165	3.4	1225	25.0
866	35.7	926	26.5	986	0.0	1046	0.0	1106	0.0	1166	4.1	1226	21.3
867	34.3	927	29.1	987	0.0	1047	0.0	1107	0.0	1167	4.4	1227	17.3
868	32.8	928	31.2	988	0.0	1048	0.0	1108	0.0	1168	3.5	1228	12.2
869	30.9	929	31.6	989	0.0	1049	0.0	1109	0.0	1169	2.0	1229	6.5
870	29.6	930	31.8	990	0.6	1050	0.0	1110	0.0	1170	0.0	1230	2.5
871	28.5	931	31.7	991	2.9	1051	0.0	1111	0.0	1171	0.0	1231	0.0
872	28.0	932	30.5	992	3.1	1052	0.0	1112	0.0	1172	0.0	1232	0.0
873	27.5	933	29.6	993	3.7	1053	0.0	1113	0.0	1173	0.0	1233	0.0
874	25.6	934	28.9	994	3.7	1054	0.0	1114	0.0	1174	0.0	1234	0.0
875	23.8	935	29.1	995	3.1	1055	0.0	1115	0.0	1175	0.0	1235	0.0
876	23.7	936	31.0	996	1.1	1056	0.0	1116	0.0	1176	0.0	1236	0.0
877	23.6	937	33.8	997	0.0	1057	0.0	1117	0.0	1177	0.0	1237	0.0
878	23.9	938	37.1	998	0.0	1058	0.0	1118	0.0	1178	0.0	1238	0.0
879	23.9	939	39.9	999	0.0	1059	0.0	1119	0.0	1179	0.0	1239	0.0
880	24.4	940	41.9	1000	0.0	1060	0.0	1120	0.0	1180	0.0	1240	1.0
881	25.3	941	43.5	1001	0.0	1061	0.0	1121	0.0	1181	0.0	1241	6.4
882	26.6	942	44.3	1002	0.0	1062	0.0	1122	0.0	1182	0.0	1242	7.4
883	27.7	943	43.7	1003	0.0	1063	0.0	1123	0.0	1183	0.0	1243	7.8
884	28.5	944	42.1	1004	0.0	1064	0.0	1124	0.0	1184	0.0	1244	10.3
885	28.4	945	39.5	1005	0.0	1065	0.0	1125	0.0	1185	0.0	1245	11.0
886	27.9	946	36.7	1006	0.0	1066	0.0	1126	0.0	1186	0.0	1246	10.6
887	27.3	947	34.3	1007	3.3	1067	0.0	1127	0.0	1187	0.0	1247	10.3
888	26.7	948	32.5	1008	6.1	1068	0.0	1128	0.0	1188	0.0	1248	10.1
889	26.3	949	31.8	1009	6.9	1069	0.0	1129	0.0	1189	5.5	1249	9.8
890	24.9	950	32.0	1010	6.6	1070	0.0	1130	0.0	1190	12.4	1250	10.0
891	22.6	951	33.1	1011	4.6	1071	0.0	1131	0.0	1191	17.1	1251	11.8
892	20.0	952	33.4	1012	2.9	1072	0.0	1132	0.0	1192	21.9	1252	14.5
893	17.5	953	33.1	1013	2.9	1073	0.0	1133	0.0	1193	26.6	1253	17.4
894	15.5	954	32.7	1014	1.1	1074	0.9	1134	0.0	1194	30.9	1254	20.2
895	14.8	955	32.3	1015	0.0	1075	2.9	1135	0.0	1195	34.7	1255	22.4
896	14.5	956	32.1	1016	0.0	1076	2.9	1136	0.0	1196	37.3	1256	23.4
897	14.6	957	31.8	1017	0.0	1077	3.1	1137	0.0	1197	39.0	1257	22.4
898	14.8	958	31.7	1018	0.0	1078	3.1	1138	0.0	1198	40.7	1258	18.0
899	14.8	959	31.6	1019	0.0	1079	2.0	1139	0.0	1199	42.3	1259	12.8
900	15.0	960	31.7	1020	0.0	1080	0.0	1140	0.0	1200	43.8	1260	7.7

UCLA Urban Dynamometer Driving Schedule (continued)

Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity
1261	4.1	1281	0.0	1301	31.4	1321	36.0	1341	36.3	1361	38.3	1381	0.0
1262	0.9	1282	0.0	1302	32.0	1322	36.4	1342	37.5	1362	38.5	1382	0.0
1263	0.0	1283	0.0	1303	32.8	1323	36.6	1343	38.7	1363	38.9	1383	0.0
1264	0.0	1284	3.9	1304	34.9	1324	36.6	1344	40.3	1364	38.6	1384	0.0
1265	0.0	1285	7.6	1305	36.6	1325	36.2	1345	41.4	1365	37.8	1385	0.0
1266	0.0	1286	11.3	1306	37.3	1326	36.8	1346	42.2	1366	36.0	1386	0.0
1267	0.0	1287	14.5	1307	37.2	1327	37.4	1347	42.5	1367	31.0	1387	0.0
1268	0.0	1288	17.3	1308	36.8	1328	37.7	1348	42.1	1368	26.4	1388	0.0
1269	0.0	1289	19.8	1309	37.1	1329	38.5	1349	41.6	1369	22.3	1389	0.0
1270	0.0	1290	21.9	1310	37.1	1330	37.7	1350	41.0	1370	18.8	1390	0.0
1271	0.0	1291	23.6	1311	37.2	1331	38.1	1351	40.2	1371	15.0	1391	0.0
1272	0.0	1292	24.5	1312	37.3	1332	37.4	1352	38.9	1372	7.6	1392	0.0
1273	0.0	1293	25.1	1313	36.7	1333	37.9	1353	37.4	1373	2.5	1393	0.0
1274	0.0	1294	26.8	1314	36.2	1334	36.9	1354	36.8	1374	0.0	1394	0.0
1275	0.0	1295	27.9	1315	35.9	1335	36.8	1355	36.5	1375	0.0	1395	0.0
1276	0.0	1296	28.1	1316	35.6	1336	37.4	1356	36.4	1376	0.0	1396	0.0
1277	0.0	1297	28.4	1317	35.4	1337	37.7	1357	37.1	1377	0.0	1397	0.0
1278	0.0	1298	29.2	1318	34.8	1338	37.4	1358	37.0	1378	0.0	1398	0.0
1279	0.0	1299	29.8	1319	34.8	1339	37.3	1359	37.5	1379	0.0	1399	0.0
1280	0.0	1300	30.5	1320	35.6	1340	36.4	1360	38.0	1380	0.0	1400	0.0

A.5.3 UCLA Acceleration Dynamometer Driving Schedule

Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity
1	0.0	61	0.0	121	0.0	181	45.0	241	46.0	301	60.0	361	30.0
2	0.0	62	0.0	122	0.0	182	44.0	242	44.0	302	60.0	362	27.0
3	0.0	63	0.0	123	0.0	183	43.0	243	42.0	303	60.0	363	24.0
4	0.0	64	0.0	124	0.0	184	45.0	244	40.0	304	60.0	364	21.0
5	0.0	65	0.0	125	0.0	185	45.0	245	38.0	305	60.0	365	18.0
6	0.0	66	0.0	126	0.0	186	45.0	246	36.0	306	60.0	366	15.0
7	0.0	67	0.0	127	0.0	187	45.0	247	34.0	307	60.0	367	13.0
8	0.0	68	0.0	128	0.0	188	45.0	248	32.0	308	60.0	368	14.0
9	0.0	69	0.0	129	0.0	189	45.0	249	30.0	309	60.0	369	15.0
10	0.0	70	0.0	130	0.0	190	45.0	250	28.0	310	60.0	370	15.0
11	0.0	71	0.0	131	0.0	191	45.0	251	26.0	311	60.0	371	15.0
12	0.0	72	0.0	132	3.0	192	45.0	252	24.0	312	60.0	372	15.0
13	0.0	73	0.0	133	6.0	193	45.0	253	22.0	313	60.0	373	15.0
14	0.0	74	0.0	134	9.0	194	45.0	254	20.0	314	60.0	374	15.0
15	0.0	75	0.0	135	12.0	195	45.0	255	18.0	315	60.0	375	15.0
16	0.0	76	0.0	136	15.0	196	45.0	256	16.0	316	60.0	376	15.0
17	0.0	77	0.0	137	18.0	197	45.0	257	14.0	317	60.0	377	15.0
18	0.0	78	0.0	138	21.0	198	45.0	258	12.0	318	58.0	378	15.0
19	0.0	79	0.0	139	24.0	199	45.0	259	10.0	319	56.0	379	15.0
20	0.0	80	0.0	140	27.0	200	45.0	260	8.0	320	54.0	380	15.0
21	0.0	81	0.0	141	30.0	201	45.0	261	6.0	321	52.0	381	15.0
22	0.0	82	0.0	142	30.0	202	45.0	262	4.0	322	50.0	382	15.0
23	0.0	83	0.0	143	30.0	203	45.0	263	2.0	323	48.0	383	15.0
24	0.0	84	0.0	144	30.0	204	45.0	264	0.0	324	50.0	384	15.0
25	0.0	85	0.0	145	30.0	205	45.0	265	0.0	325	52.0	385	15.0
26	0.0	86	0.0	146	30.0	206	45.0	266	0.0	326	54.0	386	15.0
27	0.0	87	0.0	147	30.0	207	45.0	267	0.0	327	56.0	387	15.0
28	0.0	88	0.0	148	30.0	208	45.0	268	0.0	328	58.0	388	15.0
29	0.0	89	0.0	149	30.0	209	48.0	269	0.0	329	60.0	389	18.0
30	0.0	90	0.0	150	30.0	210	51.0	270	0.0	330	60.0	390	21.0
31	0.0	91	0.0	151	30.0	211	54.0	271	0.0	331	60.0	391	24.0
32	0.0	92	0.0	152	30.0	212	57.0	272	0.0	332	61.0	392	27.0
33	0.0	93	0.0	153	30.0	213	60.0	273	0.0	333	61.0	393	30.0
34	0.0	94	0.0	154	30.0	214	60.0	274	0.0	334	61.0	394	33.0
35	0.0	95	0.0	155	30.0	215	60.0	275	0.0	335	61.0	395	36.0
36	0.0	96	0.0	156	30.0	216	60.0	276	0.0	336	61.0	396	39.0
37	0.0	97	0.0	157	33.0	217	60.0	277	0.0	337	60.0	397	42.0
38	0.0	98	0.0	158	36.0	218	60.0	278	3.0	338	57.0	398	45.0
39	0.0	99	0.0	159	39.0	219	60.0	279	6.0	339	54.0	399	48.0
40	0.0	100	0.0	160	42.0	220	60.0	280	9.0	340	51.0	400	51.0
41	0.0	101	0.0	161	45.0	221	60.0	281	12.0	341	48.0	401	54.0
42	0.0	102	0.0	162	48.0	222	60.0	282	15.0	342	45.0	402	57.0
43	0.0	103	0.0	163	51.0	223	60.0	283	18.0	343	42.0	403	60.0
44	0.0	104	0.0	164	54.0	224	60.0	284	21.0	344	39.0	404	60.0
45	0.0	105	0.0	165	57.0	225	60.0	285	24.0	345	40.0	405	60.0
46	0.0	106	0.0	166	60.0	226	60.0	286	27.0	346	40.0	406	60.0
47	0.0	107	0.0	167	60.0	227	60.0	287	30.0	347	40.0	407	60.0
48	0.0	108	0.0	168	60.0	228	60.0	288	33.0	348	40.0	408	60.0
49	0.0	109	0.0	169	60.0	229	60.0	289	36.0	349	40.0	409	57.0
50	0.0	110	0.0	170	60.0	230	60.0	290	39.0	350	40.0	410	54.0
51	0.0	111	0.0	171	60.0	231	60.0	291	42.0	351	40.0	411	51.0
52	0.0	112	0.0	172	60.0	232	60.0	292	45.0	352	40.0	412	48.0
53	0.0	113	0.0	173	60.0	233	60.0	293	48.0	353	40.0	413	45.0
54	0.0	114	0.0	174	60.0	234	60.0	294	51.0	354	40.0	414	42.0
55	0.0	115	0.0	175	60.0	235	58.0	295	54.0	355	40.0	415	42.0
56	0.0	116	0.0	176	60.0	236	56.0	296	57.0	356	40.0	416	45.0
57	0.0	117	0.0	177	57.0	237	54.0	297	60.0	357	40.0	417	48.0
58	0.0	118	0.0	178	54.0	238	52.0	298	60.0	358	40.0	418	51.0
59	0.0	119	0.0	179	51.0	239	50.0	299	60.0	359	37.0	419	54.0
60	0.0	120	0.0	180	48.0	240	48.0	300	60.0	360	33.0	420	57.0

UCLA Acceleration Dynamometer Driving Schedule (continued)

Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity
421	60.0	481	30.0	541	21.0	601	58.0	661	0.0	721	61.0	781	18.0
422	61.0	482	33.0	542	22.0	602	57.0	662	0.0	722	61.0	782	20.0
423	61.0	483	36.0	543	23.0	603	56.0	663	0.0	723	60.0	783	22.0
424	61.0	484	39.0	544	24.0	604	55.0	664	0.0	724	58.5	784	24.0
425	61.0	485	40.0	545	25.0	605	54.0	665	0.0	725	57.0	785	26.0
426	61.0	486	40.0	546	26.0	606	53.0	666	0.0	726	55.5	786	28.0
427	61.0	487	40.0	547	27.0	607	52.0	667	0.0	727	54.0	787	30.0
428	61.0	488	40.0	548	28.0	608	51.0	668	0.0	728	52.5	788	32.0
429	61.0	489	40.0	549	29.0	609	50.0	669	1.5	729	51.0	789	34.0
430	61.0	490	40.0	550	30.0	610	49.0	670	3.0	730	49.5	790	36.0
431	61.0	491	40.0	551	31.0	611	48.0	671	4.5	731	48.0	791	38.0
432	61.0	492	40.0	552	32.0	612	47.0	672	6.0	732	46.5	792	40.0
433	61.0	493	40.0	553	33.0	613	46.0	673	7.5	733	45.0	793	42.0
434	61.0	494	39.0	554	34.0	614	45.0	674	9.0	734	43.5	794	44.0
435	61.0	495	36.0	555	35.0	615	44.0	675	10.5	735	42.0	795	46.0
436	59.0	496	33.0	556	36.0	616	43.0	676	12.0	736	40.5	796	48.0
437	56.0	497	30.0	557	37.0	617	42.0	677	13.5	737	39.0	797	50.0
438	53.0	498	27.0	558	38.0	618	41.0	678	15.0	738	37.5	798	52.0
439	50.0	499	24.0	559	39.0	619	40.0	679	16.5	739	36.0	799	54.0
440	47.0	500	21.0	560	40.0	620	39.0	680	18.0	740	34.5	800	56.0
441	44.0	501	18.0	561	41.0	621	38.0	681	19.5	741	33.0	801	58.0
442	42.0	502	15.0	562	42.0	622	37.0	682	21.0	742	31.5	802	60.0
443	42.0	503	12.0	563	43.0	623	36.0	683	22.5	743	30.0	803	61.0
444	42.0	504	9.0	564	44.0	624	35.0	684	24.0	744	28.5	804	61.0
445	42.0	505	6.0	565	45.0	625	34.0	685	25.5	745	27.0	805	61.0
446	42.0	506	3.0	566	46.0	626	33.0	686	27.0	746	25.5	806	61.0
447	41.0	507	0.0	567	47.0	627	32.0	687	28.5	747	24.0	807	61.0
448	38.0	508	0.0	568	48.0	628	31.0	688	30.0	748	22.5	808	61.0
449	35.0	509	0.0	569	49.0	629	30.0	689	31.5	749	21.0	809	61.0
450	32.0	510	0.0	570	50.0	630	29.0	690	33.0	750	19.5	810	61.0
451	29.0	511	0.0	571	51.0	631	28.0	691	34.5	751	18.0	811	61.0
452	26.0	512	0.0	572	52.0	632	27.0	692	36.0	752	16.5	812	61.0
453	23.0	513	0.0	573	53.0	633	26.0	693	37.5	753	15.0	813	61.0
454	20.0	514	0.0	574	54.0	634	25.0	694	39.0	754	13.5	814	61.0
455	17.0	515	0.0	575	55.0	635	24.0	695	40.5	755	12.0	815	61.0
456	14.0	516	0.0	576	56.0	636	23.0	696	42.0	756	10.5	816	61.0
457	11.0	517	0.0	577	57.0	637	22.0	697	43.5	757	9.0	817	60.0
458	8.0	518	0.0	578	58.0	638	21.0	698	45.0	758	7.5	818	58.0
459	6.0	519	0.0	579	59.0	639	20.0	699	46.5	759	6.0	819	56.0
460	4.0	520	0.0	580	60.0	640	19.0	700	48.0	760	4.5	820	54.0
461	2.0	521	1.0	581	61.0	641	18.0	701	49.5	761	3.0	821	52.0
462	0.0	522	2.0	582	61.0	642	17.0	702	51.0	762	1.5	822	50.0
463	0.0	523	3.0	583	61.0	643	16.0	703	52.5	763	0.0	823	48.0
464	0.0	524	4.0	584	61.0	644	15.0	704	54.0	764	0.0	824	46.0
465	0.0	525	5.0	585	61.0	645	14.0	705	55.5	765	0.0	825	44.0
466	0.0	526	6.0	586	61.0	646	13.0	706	57.0	766	0.0	826	42.0
467	0.0	527	7.0	587	61.0	647	12.0	707	58.5	767	0.0	827	40.0
468	0.0	528	8.0	588	61.0	648	11.0	708	60.0	768	0.0	828	38.0
469	0.0	529	9.0	589	61.0	649	10.0	709	61.0	769	0.0	829	36.0
470	0.0	530	10.0	590	61.0	650	9.0	710	61.0	770	0.0	830	34.0
471	0.0	531	11.0	591	61.0	651	8.0	711	61.0	771	0.0	831	32.0
472	3.0	532	12.0	592	61.0	652	7.0	712	61.0	772	0.0	832	30.0
473	6.0	533	13.0	593	61.0	653	6.0	713	61.0	773	2.0	833	28.0
474	9.0	534	14.0	594	61.0	654	5.0	714	61.0	774	4.0	834	26.0
475	12.0	535	15.0	595	61.0	655	4.0	715	61.0	775	6.0	835	24.0
476	15.0	536	16.0	596	61.0	656	3.0	716	61.0	776	8.0	836	22.0
477	18.0	537	17.0	597	61.0	657	2.0	717	61.0	777	10.0	837	20.0
478	21.0	538	18.0	598	61.0	658	1.0	718	61.0	778	12.0	838	18.0
479	24.0	539	19.0	599	60.0	659	0.0	719	61.0	779	14.0	839	16.0
480	27.0	540	20.0	600	59.0	660	0.0	720	61.0	780	16.0	840	14.0

UCLA Acceleration Dynamometer Driving Schedule (continued)

Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity
841	12.0	901	15.0	961	0.0	1021	30.0	1081	60.0	1141	61.0	1201	60.0
842	10.0	902	17.5	962	0.0	1022	30.0	1082	57.5	1142	61.0	1202	61.0
843	8.0	903	20.0	963	0.0	1023	30.0	1083	55.0	1143	61.0	1203	61.0
844	6.0	904	22.5	964	0.0	1024	30.0	1084	52.5	1144	61.0	1204	61.0
845	4.0	905	25.0	965	0.0	1025	30.0	1085	50.0	1145	61.0	1205	61.0
846	2.0	906	27.5	966	2.5	1026	30.0	1086	47.5	1146	61.0	1206	61.0
847	0.0	907	30.0	967	5.0	1027	30.0	1087	45.0	1147	60.0	1207	61.0
848	0.0	908	32.5	968	7.5	1028	27.5	1088	42.5	1148	57.5	1208	61.0
849	0.0	909	35.0	969	10.0	1029	25.0	1089	40.0	1149	55.0	1209	61.0
850	0.0	910	37.5	970	12.5	1030	22.5	1090	37.5	1150	52.5	1210	61.0
851	0.0	911	40.0	971	15.0	1031	20.0	1091	35.0	1151	50.0	1211	61.0
852	0.0	912	42.5	972	17.5	1032	17.5	1092	32.5	1152	47.5	1212	61.0
853	0.0	913	45.0	973	20.0	1033	15.0	1093	30.0	1153	45.0	1213	61.0
854	0.0	914	47.5	974	22.5	1034	12.5	1094	27.5	1154	42.5	1214	60.0
855	0.0	915	50.0	975	25.0	1035	10.0	1095	25.0	1155	40.0	1215	57.0
856	0.0	916	52.5	976	27.5	1036	7.5	1096	22.5	1156	37.5	1216	54.0
857	0.0	917	55.0	977	30.0	1037	5.0	1097	20.0	1157	35.0	1217	51.0
858	0.0	918	57.5	978	30.0	1038	2.5	1098	17.5	1158	32.5	1218	48.0
859	2.0	919	60.0	979	30.0	1039	0.0	1099	15.0	1159	30.0	1219	45.0
860	4.0	920	61.0	980	30.0	1040	0.0	1100	12.5	1160	27.5	1220	42.0
861	6.0	921	61.0	981	30.0	1041	0.0	1101	10.0	1161	25.0	1221	39.0
862	8.0	922	61.0	982	30.0	1042	0.0	1102	7.5	1162	22.5	1222	36.0
863	10.0	923	61.0	983	30.0	1043	0.0	1103	5.0	1163	20.0	1223	33.0
864	12.0	924	61.0	984	30.0	1044	0.0	1104	2.5	1164	17.5	1224	30.0
865	14.0	925	61.0	985	32.5	1045	2.5	1105	0.0	1165	15.0	1225	27.0
866	16.0	926	61.0	986	35.0	1046	5.0	1106	0.0	1166	12.5	1226	24.0
867	18.0	927	61.0	987	37.5	1047	7.5	1107	0.0	1167	10.0	1227	21.0
868	20.0	928	61.0	988	40.0	1048	10.0	1108	0.0	1168	7.5	1228	18.0
869	20.0	929	61.0	989	40.0	1049	12.5	1109	0.0	1169	5.0	1229	15.0
870	20.0	930	61.0	990	40.0	1050	15.0	1110	0.0	1170	2.5	1230	12.0
871	20.0	931	61.0	991	40.0	1051	17.5	1111	2.5	1171	0.0	1231	9.0
872	20.0	932	60.0	992	40.0	1052	20.0	1112	5.0	1172	0.0	1232	6.0
873	20.0	933	57.5	993	40.0	1053	22.5	1113	7.5	1173	0.0	1233	3.0
874	20.0	934	55.0	994	42.5	1054	25.0	1114	10.0	1174	0.0	1234	0.0
875	20.0	935	52.5	995	45.0	1055	27.5	1115	12.5	1175	0.0	1235	0.0
876	20.0	936	50.0	996	47.5	1056	30.0	1116	15.0	1176	0.0	1236	0.0
877	20.0	937	47.5	997	50.0	1057	32.5	1117	17.5	1177	0.0	1237	0.0
878	20.0	938	45.0	998	50.0	1058	35.0	1118	20.0	1178	0.0	1238	0.0
879	18.0	939	42.5	999	50.0	1059	37.5	1119	22.5	1179	0.0	1239	0.0
880	16.0	940	40.0	1000	50.0	1060	40.0	1120	25.0	1180	0.0	1240	0.0
881	14.0	941	37.5	1001	50.0	1061	42.5	1121	27.5	1181	0.0	1241	0.0
882	12.0	942	35.0	1002	50.0	1062	45.0	1122	30.0	1182	3.0	1242	0.0
883	10.0	943	32.5	1003	50.0	1063	47.5	1123	32.5	1183	6.0	1243	3.0
884	8.0	944	30.0	1004	50.0	1064	50.0	1124	35.0	1184	9.0	1244	6.0
885	6.0	945	27.5	1005	50.0	1065	52.5	1125	37.5	1185	12.0	1245	9.0
886	4.0	946	25.0	1006	47.5	1066	55.0	1126	40.0	1186	15.0	1246	12.0
887	2.0	947	22.5	1007	45.0	1067	57.5	1127	42.5	1187	18.0	1247	15.0
888	0.0	948	20.0	1008	42.5	1068	60.0	1128	45.0	1188	21.0	1248	18.0
889	0.0	949	17.5	1009	40.0	1069	61.0	1129	47.5	1189	24.0	1249	21.0
890	0.0	950	15.0	1010	40.0	1070	61.0	1130	50.0	1190	27.0	1250	24.0
891	0.0	951	12.5	1011	40.0	1071	61.0	1131	52.5	1191	30.0	1251	27.0
892	0.0	952	10.0	1012	40.0	1072	61.0	1132	55.0	1192	33.0	1252	30.0
893	0.0	953	7.5	1013	40.0	1073	61.0	1133	57.5	1193	36.0	1253	33.0
894	0.0	954	5.0	1014	40.0	1074	61.0	1134	60.0	1194	39.0	1254	36.0
895	0.0	955	2.5	1015	37.5	1075	61.0	1135	61.0	1195	42.0	1255	39.0
896	2.5	956	0.0	1016	35.0	1076	61.0	1136	61.0	1196	45.0	1256	42.0
897	5.0	957	0.0	1017	32.5	1077	61.0	1137	61.0	1197	48.0	1257	45.0
898	7.5	958	0.0	1018	30.0	1078	61.0	1138	61.0	1198	51.0	1258	48.0
899	10.0	959	0.0	1019	30.0	1079	61.0	1139	61.0	1199	54.0	1259	51.0
900	12.5	960	0.0	1020	30.0	1080	61.0	1140	61.0	1200	57.0	1260	54.0

UCLA Acceleration Dynamometer Driving Schedule (continued)

Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity	Time	Velocity
1261	57.0	1281	55.0	1301	45.0	1321	35.0	1341	25.0	1361	15.0	1381	5.0
1262	60.0	1282	54.5	1302	44.5	1322	34.5	1342	24.5	1362	14.5	1382	4.5
1263	60.0	1283	54.0	1303	44.0	1323	34.0	1343	24.0	1363	14.0	1383	4.0
1264	60.0	1284	53.5	1304	43.5	1324	33.5	1344	23.5	1364	13.5	1384	3.5
1265	60.0	1285	53.0	1305	43.0	1325	33.0	1345	23.0	1365	13.0	1385	3.0
1266	60.0	1286	52.5	1306	42.5	1326	32.5	1346	22.5	1366	12.5	1386	2.5
1267	60.0	1287	52.0	1307	42.0	1327	32.0	1347	22.0	1367	12.0	1387	2.0
1268	60.0	1288	51.5	1308	41.5	1328	31.5	1348	21.5	1368	11.5	1388	1.5
1269	60.0	1289	51.0	1309	41.0	1329	31.0	1349	21.0	1369	11.0	1389	1.0
1270	60.0	1290	50.5	1310	40.5	1330	30.5	1350	20.5	1370	10.5	1390	0.5
1271	60.0	1291	50.0	1311	40.0	1331	30.0	1351	20.0	1371	10.0	1391	0.0
1272	59.5	1292	49.5	1312	39.5	1332	29.5	1352	19.5	1372	9.5	1392	0.0
1273	59.0	1293	49.0	1313	39.0	1333	29.0	1353	19.0	1373	9.0	1393	0.0
1274	58.5	1294	48.5	1314	38.5	1334	28.5	1354	18.5	1374	8.5	1394	0.0
1275	58.0	1295	48.0	1315	38.0	1335	28.0	1355	18.0	1375	8.0	1395	0.0
1276	57.5	1296	47.5	1316	37.5	1336	27.5	1356	17.5	1376	7.5	1396	0.0
1277	57.0	1297	47.0	1317	37.0	1337	27.0	1357	17.0	1377	7.0	1397	0.0
1278	56.5	1298	46.5	1318	36.5	1338	26.5	1358	16.5	1378	6.5	1398	0.0
1279	56.0	1299	46.0	1319	36.0	1339	26.0	1359	16.0	1379	6.0	1399	0.0
1280	55.5	1300	45.5	1320	35.5	1340	25.5	1360	15.5	1380	5.5	1400	0.0

A.6 Determination of Emission Rates During Rich Open Loop Operation

A.6.1 Analysis of Rich Open Loop Emission Rates During Cold Start Bag of UCLA Acceleration Cycle

Open loop	Speed	Lambda	HC	CO	NOx
1 = open loop	mph		g/s	g/s	g/s
1	41.9	0.80	.0541	1.1910	.0149
1	46.09	0.80	.0701	1.9190	.0141
1	49.64	0.80	.0849	2.7220	.0150
1	53.05	0.79	.0950	3.5860	.0193
1	56.38	0.78	.0918	4.1900	.0773
0		0.98	.0709	3.6430	.1271
0		1.10	.0351	1.5200	.0835
0		1.03	.0290	.8113	.0322
0		1.00	.0234	.3258	.0123
0		0.99	.0172	.1560	.0057
0		0.99	.0130	.0927	.0017
0		0.98	.0102	.0764	.0017
0		1.00	.0084	.0917	
0		1.01	.0072	.0584	
0		1.02	.0060	.0403	
0		1.03	.0049	.0287	
0		1.08	.0039	.0204	
0		1.08	.0030	.0140	
			.0023		
			.0019		
			.0019		
			.0021		
			.0030		
			.0040		
			.0045		
			.0044		
			.0039		
			.0035		
			.0032		
			.0023		
			.0025		
			.0025		
			.0024		
			.0024		
			.0024		
			.0024		
			.0023		
			.0022		
			.0022		
			.0022		
			.0022		
			.0021		
			.0021		
			.0021		
			.0021		
	Sum		.6992	20.4867	.4048
	Minus Baseline		.0560	.1547	.0112
	g / s		.1286	4.0664	.0787

Analysis of Rich Open Loop Emission Rates During Cold Start Bag of UCLA Acceleration Cycle (continued)

Open loop	Speed	Lambda	HC	CO	NOx
1 = open loop	mph		g/s	g/s	g/s
1	46.3	0.94	0.0135	0.4392	0.0042
1	47.94	0.82	0.0246	0.8171	0.0075
1	51.8	0.81	0.0414	2.0690	0.0090
1	55.35	0.80	0.0593	3.3120	0.0191
1	58.41	0.85	0.0628	4.4670	0.0928
0		1.03	0.0444	3.7240	0.1465
0		1.11	0.0262	0.2917	0.1090
0		1.03	0.0161	0.3220	0.0554
0		1.01	0.0107	0.2421	0.0209
0		1.00	0.0075	0.1184	0.0082
0		1.02	0.0056	0.0712	0.0040
0		1.00	0.0033	0.0662	
0		1.01	0.0036	0.0730	
0		1.01	0.0033	0.0494	
0		1.01	0.0030	0.0383	
0		1.00	0.0029	0.0322	
0		0.99	0.0029	0.0283	
0		0.99	0.0029	0.0250	
0		1.00	0.0028	0.0218	
0		1.00	0.0027	0.0189	
0		0.99	0.0027		
0		1.00	0.0026		
0		0.99	0.0026		
0		1.00	0.0025		
0		1.00	0.0024		
0		1.04	0.0021		
0		1.05	0.0017		
	Sum		.3561	16.2268	.4766
	Minus Baseline		.0308	.1785	.0096
	g / s		.0651	3.2097	.0934
1	40.98	0.83	.0115	.2068	.0097
1	45.13	0.83	.0128	1.3820	.0164
1	48.79	0.91	.0084	1.4300	.0377
0		1.00	.0097	.8601	.0495
0		1.03	.0087	.3979	.0364
0		1.02	.0075	.1924	.0211
0		1.03	.0063	.1069	.0093
0		1.00	.0051	.1692	.0022
0		1.02	.0039	.1188	.0024
0		1.02	.0030	.0541	.0017
0		1.02	.0024	.0291	
0		1.01	.0021	.0132	
	Sum		.0814	4.9605	.1864
	Minus Baseline		.0126	.1071	.0112
	g / s		.0229	1.6178	.0584

Analysis of Rich Open Loop Emission Rates During Cold Start Bag of UCLA Acceleration Cycle (continued)

Open loop	Speed	Lambda	HC	CO	NOx
1 = open loop	mph		g/s	g/s	g/s
1	52.83	0.84	.0106	.0779	.0070
1	55.43	0.82	.0196	.8147	.0102
0		0.96	.0196	2.4440	.0103
0		1.06	.0106	1.5040	.0052
0		1.05	.0072	.5622	.0028
0		1.01	.0047	.1900	.0023
0		1.02	.0035	.0874	
0		1.00	.0029	.0517	
0		1.01	.0024	.0966	
0		1.02	.0020	.0593	
0		1.02	.0017	.0329	
0		1.00	.0015	.0200	
0		1.00	.0019	.0124	
	Sum		.0882	5.9531	.0378
	Minus Baseline		.0154	.1309	.0064
	g / s		.0364	2.9111	.0157
1	49.71	0.84	.0147	.2499	.0094
1	52.83	0.83	.0240	2.0320	.0120
1	56.53	0.82	.0310	3.2410	.0448
0		1.00	.0248	3.3880	.0723
0		1.10	.0129	1.9130	.0464
0		1.04	.0063	.6775	.0162
0		1.02	.0042	.2356	.0059
0		1.02	.0027	.0990	
0		1.04	.0018	.0510	
0		1.01		.0458	
0		1.01		.0372	
0		1.04		.0173	
	Sum		.1224	11.9873	.2070
	Minus Baseline		.0084	.1071	.0064
	g / s		.0380	3.9601	.0669

Analysis of Rich Open Loop Emission Rates During Cold Start Bag of UCLA Acceleration Cycle (continued)

Open loop	Speed	Lambda	HC	CO	NOx
1 = open loop	mph		g/s	g/s	g/s
1	45.44	0.86	.0111	.0509	.0054
1	48.8	0.84	.0244	.5234	.0083
1	52.89	0.83	.0400	2.7830	.0155
1	56.33	0.82	.0463	3.9080	.0336
0		1.01	.0352	3.4960	.0368
0		1.09	.0206	1.8530	.0189
0		1.02	.0104	.6693	.0066
0		1.01	.0059	.2651	.0017
0		1.01	.0046	.1282	.0017
0		1.02	.0033	.0767	
0		1.01	.0025	.0686	
0		1.01	.0020	.0732	
0		1.00	.0019	.0470	
0		1.00	.0021	.0355	
0		1.01	.0022	.0291	
0		1.00	.0022	.0254	
0		1.01	.0021	.0232	
0		1.00	.0019	.0217	
0		1.01	.0016	.0193	
0		1.01		.0150	
	Sum		.2203	14.1116	.1285
	Minus Baseline		.0210	.1904	.0080
	g / s		.0498	3.4803	.0301
1	46.19	0.90	.0113	.0109	.0025
1	47.62	0.84	.0122	.8956	.0096
1	51.34	0.83	.0166	2.3400	.0261
0		0.98	.0101	2.4750	.0337
0		1.08	.0080	1.4170	.0217
0		1.01	.0055	.6080	.0093
0		1.00	.0038	.2474	.0021
0		1.01	.0027	.1170	.0023
0		1.01	.0017	.0677	.0017
0		1.01		.1113	
0		1.00		.0595	
0		0.99		.0356	
0		0.98		.0255	
0		0.98		.0201	
0		0.98		.0166	
	Sum		.0719	8.4472	.1090
	Minus Baseline		.0084	.1428	.0096
	g / s		.0212	2.7681	.0331

Analysis of Rich Open Loop Emission Rates During Cold Start Bag of UCLA Acceleration Cycle (continued)

Open loop	Speed	Lambda	HC	CO	NOx
1 = open loop	mph		g/s	g/s	g/s
1	52.83	0.84	.0106	.0779	.0070
1	55.43	0.82	.0196	.8147	.0102
0		0.96	.0196	2.4440	.0103
0		1.06	.0106	1.5040	.0052
0		1.05	.0072	.5622	.0028
0		1.01	.0047	.1900	.0023
0		1.02	.0035	.0874	
0		1.00	.0029	.0517	
0		1.01	.0024	.0966	
0		1.02	.0020	.0593	
0		1.02	.0017	.0329	
0		1.00	.0015	.0200	
0		1.00	.0019	.0124	
	Sum		.0882	5.9531	.0378
	Minus Baseline		.0154	.1309	.0064
	g / s		.0364	2.9111	.0157
1	49.71	0.84	.0147	.2499	.0094
1	52.83	0.83	.0240	2.0320	.0120
1	56.53	0.82	.0310	3.2410	.0448
0		1.00	.0248	3.3880	.0723
0		1.10	.0129	1.9130	.0464
0		1.04	.0063	.6775	.0162
0		1.02	.0042	.2356	.0059
0		1.02	.0027	.0990	
0		1.04	.0018	.0510	
0		1.01		.0458	
0		1.01		.0372	
0		1.04		.0173	
	Sum		.1224	11.9873	.2070
	Minus Baseline		.0084	.1071	.0064
	g / s		.0380	3.9601	.0669

Analysis of Rich Open Loop Emission Rates During Cold Start Bag of UCLA Acceleration Cycle (continued)

Open loop	Speed	Lambda	HC	CO	NOx
1 = open loop	mph		g/s	g/s	g/s
1	45.44	0.86	.0111	.0509	.0054
1	48.8	0.84	.0244	.5234	.0083
1	52.89	0.83	.0400	2.7830	.0155
1	56.33	0.82	.0463	3.9080	.0336
0		1.01	.0352	3.4960	.0368
0		1.09	.0206	1.8530	.0189
0		1.02	.0104	.6693	.0066
0		1.01	.0059	.2651	.0017
0		1.01	.0046	.1282	.0017
0		1.02	.0033	.0767	
0		1.01	.0025	.0686	
0		1.01	.0020	.0732	
0		1.00	.0019	.0470	
0		1.00	.0021	.0355	
0		1.01	.0022	.0291	
0		1.00	.0022	.0254	
0		1.01	.0021	.0232	
0		1.00	.0019	.0217	
0		1.01	.0016	.0193	
0		1.01		.0150	
	Sum		.2203	14.1116	.1285
	Minus Baseline		.0210	.1904	.0080
	g / s		.0498	3.4803	.0301
1	46.19	0.90	.0113	.0109	.0025
1	47.62	0.84	.0122	.8956	.0096
1	51.34	0.83	.0166	2.3400	.0261
0		0.98	.0101	2.4750	.0337
0		1.08	.0080	1.4170	.0217
0		1.01	.0055	.6080	.0093
0		1.00	.0038	.2474	.0021
0		1.01	.0027	.1170	.0023
0		1.01	.0017	.0677	.0017
0		1.01		.1113	
0		1.00		.0595	
0		0.99		.0356	
0		0.98		.0255	
0		0.98		.0201	
0		0.98		.0166	
	Sum		.0719	8.4472	.1090
	Minus Baseline		.0084	.1428	.0096
	g / s		.0212	2.7681	.0331

Analysis of Rich Open Loop Emission Rates During Cold Start Bag of UCLA Acceleration Cycle (continued)

Open loop	Speed	Lambda	HC	CO	NOx
1 = open loop	mph		g/s	g/s	g/s
1	48.69	0.87	.0069	.0127	.0026
1	51	0.84	.0120	.5559	.0039
1	52.83	0.84	.0167	1.2470	.0046
1	54.77	0.83	.0262	2.8040	.0060
1	58.66	0.88	.0289	4.0950	.0342
0		1.06	.0203	3.3440	.0878
0		1.17	.0083	1.3800	.1163
0		1.11	.0052	.4281	.0901
0		1.04	.0032	.2261	.0297
0		0.97	.0021	.1051	.0163
0		0.97	.0015	.0636	.0068
0		0.97		.0635	.0037
0		0.97		.0739	.0027
0		0.97		.0496	
0		0.96		.0373	
0		0.97		.0300	
0		0.99		.0244	
0		0.95		.0187	
0		0.90		.0130	
	Sum		.1313	14.5719	.4047
	Minus Baseline		.0084	.1666	.0128
	g / s		.0246	2.8811	.0784
1	48.04	0.84	.0124	.3715	.0095
1	51.27	0.83	.0159	2.2510	.0308
0		0.94	.0117	2.6470	.0441
0		1.08	.0084	1.6980	.0307
0		1.01	.0058	.7383	.0151
0		1.00	.0039	.2856	.0045
0		1.01	.0027	.1277	.0021
0		1.00	.0018	.0709	.0019
0		1.00	.0015	.1032	
0		0.99		.0678	
0		0.99		.0382	
0		1.01		.0256	
0		0.97		.0192	
0		0.97		.0155	
	Sum		.0641	8.4595	.1387
	Minus Baseline		.0098	.1428	.0096
	g / s		.0272	4.1584	.0646

Analysis of Rich Open Loop Emission Rates During Cold Start Bag of UCLA Acceleration Cycle (continued)

Open loop	Speed	Lambda	HC	CO	NOx
1 = open loop	mph		g/s	g/s	g/s
1	51.12	0.85	.0133	.0176	.0085
1	53.08	0.83	.0192	1.6490	.0044
1	57.15	0.83	.0271	3.6130	.0124
0		1.02	.0230	3.6430	.0661
0		1.15	.0112	2.0850	.1070
0		1.13	.0056	.8141	.0932
0		1.05	.0036	.3066	.0305
0		0.99	.0024	.1308	.0192
0		0.99	.0017	.0724	.0084
0		0.98		.0504	.0047
0		0.97		.0874	.0031
0		0.97		.0529	
0		0.96		.0375	
0		0.97		.0295	
0		1.00		.0239	
0		0.94		.0185	
0		0.93		.0128	
	Sum		.1071	12.6444	.3575
	Minus Baseline		.0084	.1666	.0128
	g / s		.0329	4.1593	.1149
1	51.72	0.87	.0125	.0181	.0104
1	53.01	0.84	.0174	1.1540	.0052
1	56.39	0.82	.0270	3.1130	.0088
0		0.98	.0247	3.7540	.0584
0		1.13	.0136	2.3460	.1192
0		1.13	.0055	.9138	.1088
0		1.05	.0038	.3221	.0467
0		0.99	.0023	.1279	.0205
0		0.96	.0015	.0656	.0079
0		0.96		.0424	.0040
0		0.96		.0673	.0026
0		0.97		.0447	
0		0.95		.0306	
0		0.91		.0209	
0		0.88		.0134	
	Sum		.1083	12.0338	.3925
	Minus Baseline		.0084	.1428	.0128
	g / s		.0333	3.9637	.1266

A.6.2 Analysis of Rich Open Loop Emission Rates During Hot Running Bag of UCLA Acceleration Cycle

Open loop	Speed	Lambda	HC	CO	NOx
1 = open loop	mph		g/s	g/s	g/s
1	40.35	0.84	0.0145	0.0102	0.0087
1	44.11	0.85	0.0274	1.5800	0.0088
0		1.01	0.0355	2.9400	0.0147
0		1.04	0.0311	3.3290	0.0418
0		1.05	0.0215	2.3270	0.1059
0		1.00	0.0155	1.1460	0.1348
0		1.00	0.0083	0.5619	0.0710
0		1.00	0.0081	0.2862	0.0574
0		1.00	0.0057	0.1633	0.0448
0		1.01	0.0039	0.0998	0.0378
0		0.97	0.0027	0.1517	0.0299
0		1.00	0.0018	0.0786	0.0251
0		0.98		0.0450	0.0248
0		0.97		0.0307	0.0196
0		0.98		0.0249	0.0114
0		0.97		0.0217	0.0060
0		0.97		0.0185	0.0042
0		0.92		0.0123	0.0030
0		0.90			0.0020
	Sum		.1760	12.8268	.6517
	Minus Baseline		.0140	.1904	.0272
	g / s		.0810	6.3182	.3123

Analysis of Rich Open Loop Emission Rates During Hot Running Bag of UCLA Acceleration Cycle (continued)

Open loop	Speed	Lambda	HC	CO	NOx
1	47.4	0.86	0.0045	0.0017	0.0016
1	50.63	0.83	0.0097	0.2333	0.0018
1	54.42	0.83	0.0196	2.2600	0.0029
1	57.45	0.88	0.0281	3.9550	0.0142
0		1.06	0.0245	4.3140	0.0820
0		1.14	0.0120	2.1490	0.1108
0		1.04	0.0060	0.2444	0.0806
0		0.99	0.0038	0.3069	0.0492
0		0.98	0.0024	0.1665	0.0323
0		0.97	0.0016	0.0873	0.0191
0		0.97		0.0559	0.0136
0		0.97		0.0755	0.0145
0		0.97		0.0601	0.0141
0		0.97		0.0430	0.0095
0		0.97		0.0340	0.0052
0		0.98		0.0280	0.0030
0		0.97		0.0235	0.0028
0		0.98		0.0199	0.0049
0		0.98		0.0171	0.0071
0		0.98			0.0076
0		0.98			0.0078
0		0.98			0.0065
0		0.98			0.0063
0		0.98			0.0056
0		0.99			0.0039
0		0.98			0.0026
	Sum		.1122	14.0751	.5095
	Minus Baseline		.0084	.1785	.0352
	g / s		.0260	3.4742	.1186

Analysis of Rich Open Loop Emission Rates During Hot Running Bag of UCLA Acceleration Cycle (continued)

Open loop	Speed	Lambda	HC	CO	NOx
1	51.18	0.86	0.0128	0.0151	0.0024
1	52.43	0.84	0.0185	1.3970	0.0040
1	56.09	0.82	0.0276	3.6000	0.0077
0		0.96	0.0254	4.3800	0.0568
0		1.12	0.0129	2.9070	0.1076
0		1.11	0.0064	0.8006	0.1196
0		1.04	0.0040	0.3512	0.0850
0		0.97	0.0025	0.1639	0.0308
0		0.96	0.0016	0.0809	0.0147
0		0.96		0.0491	0.0060
0		0.96		0.0628	0.0034
0		0.96		0.0484	0.0026
0		0.97		0.0351	0.0021
0		0.97		0.0291	
0		0.97		0.0254	
0		0.99		0.0225	
0		0.98		0.0197	
0		0.98		0.0171	
	Sum		.1117	14.0049	.4427
	Minus Baseline		.0084	.1785	.0160
	g / s		.0344	4.6088	.1422
1	53.89	0.84	0.0042	0.0204	0.0031
1	56.05	0.84	0.0047	0.4759	0.0044
0		0.93	0.0037	0.2904	0.0040
0		1.01	0.0029	0.2973	0.0028
0		1.02	0.0023	0.1163	0.0018
0		1.02	0.0022	0.0557	
0		1.00	0.0017	0.1148	
0		1.00		0.0731	
0		0.98		0.0336	
0		0.98		0.0164	
	Sum		.0217	1.4939	.0161
	Minus Baseline		.0070	.0952	.0048
	g / s		.0074	.6994	.0057
1	51.21	0.84	0.0225	2.8230	0.0281
1	52.41	0.83	0.0204	3.4620	0.0593
1	56.35	0.82	0.0096	2.3540	0.0587
0		0.99	0.0069	1.0070	0.0308
0		1.13	0.0043	0.3706	0.0118
0		1.09	0.0027	0.1519	0.0030
0		1.02	0.0019	0.0830	
0		0.97		0.0693	
0		0.86		0.0784	
0		0.88		0.0365	
0		0.86		0.0187	
	Sum		.0683	10.4544	.1917
	Minus Baseline		.0056	.0952	.0048
	g / s		.0209	3.4531	.0623

Analysis of Rich Open Loop Emission Rates During Hot Running Bag of UCLA Acceleration Cycle (continued)

Open loop	Speed	Lambda	HC	CO	NOx
1	46.07	0.84	0.0136	0.0623	0.0031
1	50.22	0.83	0.0285	1.3330	0.0045
1	53.67	0.83	0.0448	3.8120	0.0067
1	56.85	0.83	0.0538	5.2490	0.0173
0		1.02	0.0454	2.8270	0.0639
0		1.15	0.0268	0.2650	0.1098
0		1.09	0.0148	0.2099	0.0965
0		1.01	0.0071	0.2359	0.0534
0		0.98	0.0051	0.2256	0.0276
0		0.95	0.0035	0.1258	0.0167
0		0.96	0.0024	0.0762	0.0081
0		0.96	0.0015	0.0588	0.0037
0		0.96		0.0536	0.0019
0		0.96		0.0389	
0		0.98		0.0358	
0		0.98		0.0349	
0		0.97		0.0329	
0		0.97		0.0289	
0		0.94		0.0229	
0		0.92		0.0161	
	Sum		.2473	14.7445	.4132
	Minus Baseline		.0112	.1904	.0144
	g / s		.0590	3.6385	.0997
1	50.2	0.92	0.0100	0.5224	0.0174
0		0.99	0.0102	1.6930	0.0351
0		1.00	0.0067	1.3230	0.0251
0		1.00	0.0048	0.6025	0.0209
0		1.02	0.0033	0.2291	0.0270
0		1.02	0.0025	0.1009	0.0185
0		1.01	0.0019	0.0611	0.0096
0		1.01	0.0016	0.1166	0.0036
0		1.00		0.0813	
0		1.00		0.0455	
0		0.99		0.0297	
0		0.98		0.0206	
	Sum		.0410	4.8257	.1572
	Minus Baseline		.0098	.1428	.0112
	g / s		.0312	4.6829	.1460

Analysis of Rich Open Loop Emission Rates During Hot Running Bag of UCLA Acceleration Cycle (continued)

Open loop	Speed	Lambda	HC	CO	NOx
1	44.88	0.89	0.0062	0.0039	0.0095
1	46.96	0.84	0.0114	0.0185	0.0090
0		0.98	0.0132	1.6950	0.0279
0		1.07	0.0092	2.3230	0.0655
0		1.07	0.0080	1.5910	0.0715
0		1.01	0.0056	0.7413	0.0446
0		0.98	0.0038	0.3004	0.0201
0		1.00	0.0026	0.1382	0.0096
0		0.97	0.0020	0.0767	0.0048
0		0.98		0.1164	0.0020
0		0.97		0.0727	0.0023
0		0.98		0.0389	0.0020
0		0.96		0.0257	
0		0.95		0.0194	
0		0.96		0.0133	
	Sum		.0620	7.1744	.2688
	Minus Baseline		.0098	.1666	.0160
	g / s		.0261	3.5039	.1264
1	39.62	0.87	0.0021	0.0103	0.0120
0		0.97	0.0030	0.0080	0.0085
0		1.03	0.0062	0.0073	0.0060
0		1.02	0.0120	0.0280	0.0091
0		0.99	0.0089	1.7980	0.0304
0		0.98	0.0086	1.9640	0.0659
0		0.98	0.0071	1.1870	0.0671
0		0.99	0.0051	0.5354	0.0411
0		1.01	0.0036	0.2211	0.0189
0		1.01	0.0025	0.1087	0.0088
0		1.01	0.0019	0.0900	0.0022
0		1.01		0.1212	0.0020
0		0.99		0.0556	0.0018
0		1.00		0.0318	
0		0.98		0.0216	
0		0.97		0.0140	
	Sum		.0610	6.2020	.2738
	Minus Baseline		.0140	.1904	.0192
	g / s		.0470	6.0116	.2546

Analysis of Rich Open Loop Emission Rates During Hot Running Bag of UCLA Acceleration Cycle (continued)

Open loop	Speed	Lambda	HC	CO	NOx
1	42.87	0.89	0.0037	0.0088	0.0096
1	45.82	0.84	0.0068	0.0084	0.0046
1	49.74	0.84	0.0130	0.0211	0.0028
1	53.17	0.83	0.0222	1.8210	0.0040
1	56.45	0.82	0.0361	3.9060	0.0052
0		0.95	0.0408	5.2050	0.0134
0		1.12	0.0293	3.7640	0.0617
0		1.15	0.0153	0.2474	0.1056
0		1.06	0.0060	0.1914	0.0922
0		0.99	0.0044	0.2339	0.0411
0		0.95	0.0030	0.1409	0.0207
0		0.94	0.0022	0.0864	0.0083
0		0.95	0.0017	0.0624	0.0046
0		0.95		0.0929	0.0030
0		0.96		0.0637	
0		0.97		0.0425	
0		0.97		0.0305	
0		0.93		0.0230	
0		0.96		0.0171	
	Sum		.1845	15.9664	.3768
	Minus Baseline		.0112	.1666	.0144
	g / s		.0347	3.1600	.0725
1	51.12	0.84	0.0155	0.0300	0.0061
1	55.04	0.82	0.0241	2.2610	0.0044
0		0.94	0.0297	4.0280	0.0218
0		1.11	0.0214	3.4780	0.0788
0		1.14	0.0092	1.6740	0.1125
0		1.07	0.0050	0.5927	0.0919
0		1.00	0.0031	0.2258	0.0350
0		0.98	0.0020	0.1023	0.0180
0		0.97		0.0607	0.0075
0		0.96		0.0545	0.0042
0		0.96		0.0717	0.0031
0		0.93		0.0456	0.0026
0		0.90		0.0295	
0		0.85		0.0183	
	Sum		.1100	12.6721	.3859
	Minus Baseline		.0084	.1428	.0160
	g / s		.0508	6.2647	.1850

A.6.3 Analysis of Rich Open Loop Emission Rates During Warm Start Bag of UCLA Acceleration Cycle

Open loop	Speed	Lambda	HC	CO	NOx
1 = open loop	mph		g/s	g/s	g/s
1	37.4	0.90	0.0069	0.0006	0.0104
1	40.93	0.84	0.0150	0.0218	0.0098
1	44.9	0.84	0.0218	2.0380	0.0194
1	48.42	0.85	0.0187	2.4190	0.0434
0		1.02	0.0109	1.5090	0.0676
0		1.08	0.0081	0.6953	0.0810
0		1.07	0.0070	0.3146	0.0719
0		0.99	0.0055	0.1704	0.0379
0		0.99	0.0042	0.1105	0.0165
0		0.99	0.0032	0.1767	0.0082
0		0.99	0.0024	0.1185	0.0028
0		0.97	0.0016	0.0654	0.0024
0		0.96		0.0409	0.0022
0		0.97		0.0280	0.0017
0		0.97		0.0207	
0		0.97		0.0136	
	Sum		.1053	7.7430	.3752
	Minus Baseline		.0112	.1428	.0160
	g / s		.0235	1.9001	.0898
1	48.08	0.84	0.0063	0.0059	0.0020
1	51.72	0.83	0.0127	1.0120	0.0025
1	55.32	0.82	0.0263	2.7520	0.0036
1	57.72	0.93	0.0336	4.4580	0.0185
0		1.09	0.0261	4.0850	0.0695
0		1.12	0.0143	1.0410	0.0759
0		1.03	0.0051	0.2188	0.0498
0		0.99	0.0042	0.2770	0.0332
0		0.98	0.0026	0.1459	0.0193
0		0.98	0.0018	0.0826	0.0089
0		0.98		0.0552	0.0044
0		0.98		0.0810	0.0022
0		0.97		0.0569	0.0009
0		0.97		0.0420	
0		0.98		0.0338	
0		0.98		0.0282	
0		0.98		0.0239	
0		0.98		0.0202	
0		0.99		0.0169	
	Sum		.1330	14.4363	.2907
	Minus Baseline		.0084	.1785	.0144
	g / s		.0312	3.5645	.0691

Analysis of Rich Open Loop Emission Rates During Warm Start Bag of UCLA Acceleration Cycle (continued)

Open loop	Speed	Lambda	HC	CO	NOx
1 = open loop	mph		g/s	g/s	g/s
1	49.07	0.88	0.0054	0.0080	0.0225
1	50.96	0.83	0.0116	0.0121	0.0109
1	55	0.82	0.0142	0.7032	0.0076
1	58.12	0.89	0.0234	2.7380	0.0124
0		1.08	0.0230	3.7930	0.0605
0		1.16	0.0122	2.6470	0.1125
0		1.08	0.0062	1.0980	0.1158
0		1.02	0.0038	0.3974	0.0548
0		0.95	0.0023	0.1485	0.0299
0		0.95		0.0717	0.0121
0		0.95		0.0439	0.0070
0		0.95		0.0637	0.0045
0		0.97		0.0506	0.0030
0		0.97		0.0361	0.0023
0		0.97		0.0289	
0		0.98		0.0242	
0		0.98		0.0206	
0		0.98		0.0175	
0		0.98		0.0150	
	Sum		.1021	11.9174	.4558
	Minus Baseline		.0070	.1785	.0160
	g / s		.0238	2.9347	.1100
1	52.54	0.89	0.0030	0.0049	0.0019
1	55.05	0.86	0.0088	0.0211	0.0028
0		1.00	0.0098	1.2320	0.0041
0		1.01	0.0089	1.4010	0.0039
0		1.00	0.0071	0.9856	0.0031
0		1.02	0.0050	0.4291	0.0022
0		1.01	0.0032	0.1703	
0		1.01	0.0022	0.0784	
0		0.99		0.0443	
0		0.98		0.0874	
0		0.98		0.0464	
0		0.98		0.0251	
0		0.95		0.0148	
	Sum		.0480	4.5404	.0180
	Minus Baseline		.0084	.1309	.0064
	g / s		.0198	2.2048	.0058

Analysis of Rich Open Loop Emission Rates During Warm Start Bag of UCLA Acceleration Cycle (continued)

Open loop	Speed	Lambda	HC	CO	NOx
1 = open loop	mph		g/s	g/s	g/s
1	44.38	0.90	0.0023	0.0092	0.0396
1	46.55	0.84	0.0034	0.0087	0.0281
1	50.83	0.83	0.0058	0.0080	0.0142
1	54.15	0.90	0.0123	0.0185	0.0076
0		1.07	0.0181	1.3580	0.0032
0		1.04	0.0263	3.3290	0.0182
0		0.96	0.0225	3.7890	0.0813
0		1.00	0.0104	2.2170	0.1355
0		1.00	0.0056	0.8262	0.1170
0		1.00	0.0032	0.2803	0.0530
0		0.95	0.0019	0.1058	0.0260
0		0.90		0.0503	0.0117
0		0.93		0.0305	0.0046
0		0.92		0.0343	0.0022
0		0.96		0.0164	
	Sum		.1118	12.0812	.5422
	Minus Baseline		.0098	.1309	.0160
	g / s		.0255	2.9876	.1316
1	45.49	0.84	0.0059	0.0437	0.0028
1	49.18	0.84	0.0155	0.2776	0.0049
1	52.85	0.83	0.0305	2.3510	0.0067
1	56.2	0.82	0.0452	4.1200	0.0130
1	58.87	0.93	0.0494	5.2320	0.0353
0		1.11	0.0358	1.6920	0.0831
0		1.16	0.0197	0.2467	0.1010
0		1.05	0.0103	0.2079	0.0689
0		0.99	0.0049	0.2572	0.0404
0		0.98	0.0039	0.1536	0.0174
0		0.95	0.0026	0.0898	0.0072
0		0.90	0.0019	0.0613	0.0036
0		0.90	0.0015	0.0776	0.0025
0		0.94		0.0620	
0		0.97		0.0481	
0		0.97		0.0396	
0		0.98		0.0334	
0		0.98		0.0282	
0		0.97		0.0231	
0		0.96		0.0174	
	Sum		.2271	15.0622	.3868
	Minus Baseline		.0112	.1785	.0128
	g / s		.0432	2.9767	.0748

Analysis of Rich Open Loop Emission Rates During Warm Start Bag of UCLA Acceleration Cycle (continued)

Open loop	Speed	Lambda	HC	CO	NOx
1 = open loop	mph		g/s	g/s	g/s
1	48.96	0.84	0.0022	0.0041	0.0075
1	52.64	0.92	0.0019	0.0618	0.0055
0		1.06	0.0021	0.1640	0.0025
0		1.01	0.0020	0.1628	0.0039
0		1.01	0.0019	0.1732	0.0054
0		1.01	0.0016	0.1210	0.0062
0		1.00		0.0608	0.0049
0		1.00		0.0177	0.0031
0		1.00			0.0020
	Sum		.0117	.7654	.0410
	Minus Baseline		.0056	.0714	.0112
	g / s		.0031	.3470	.0149
1	45.73	0.86	0.0100	0.1422	0.0111
1	48.05	0.84	0.0090	1.6870	0.0196
1	52.01	0.90	0.0069	1.3170	0.0414
0		1.06	0.0053	0.7064	0.0466
0		1.05	0.0041	0.3139	0.0312
0		1.00	0.0029	0.1459	0.0151
0		1.01	0.0022	0.0773	0.0051
0		1.00	0.0016	0.1628	0.0021
0		1.01		0.0767	0.0019
0		0.99		0.0386	
0		0.97		0.0243	
	Sum		.0420	4.6921	.1741
	Minus Baseline		.0070	.0952	.0096
	g / s		.0117	1.5323	.0548
1	41.18	0.84	0.0054	0.0075	0.0117
1	45.06	0.93	0.0054	0.1077	0.0158
0		1.04	0.0044	0.7554	0.0226
0		1.02	0.0036	0.4401	0.0236
0		1.00	0.0028	0.2005	0.0193
0		0.94	0.0025	0.0854	0.0142
1	55.89	0.84	0.0020	0.1309	0.0104
1	58.05	0.89	0.0017	0.1482	0.0058
0		1.01		0.0666	0.0022
0		1.01		0.0253	0.0025
0		1.02		0.0161	0.0021
0		1.01		0.0124	
	Sum		.0278	1.9961	.1302
	Minus Baseline		.0056	.0952	.0112
	g / s		.0056	.4752	.0298

Analysis of Rich Open Loop Emission Rates During Warm Start Bag of UCLA Acceleration Cycle (continued)

Open loop	Speed	Lambda	HC	CO	NOx
1 = open loop	mph		g/s	g/s	g/s
1	45.43	0.84	0.0035	0.3220	0.0285
1	48.56	0.84	0.0028	0.1399	0.0353
0		0.94	0.0025	0.0659	0.0364
0		1.07	0.0022	0.1824	0.0349
0		1.05	0.0021	0.1173	0.0307
0		1.00	0.0019	0.0620	0.0260
0		1.00	0.0017	0.0209	0.0172
0		1.00		0.0246	0.0107
0		0.99		0.0174	0.0101
0		0.98		0.0120	0.0135
0		0.95			0.0181
0		0.98			0.0111
0		0.97			0.0054
0		0.98			0.0023
	Sum		.0167	.9644	.2802
	Minus Baseline		.0070	.0952	.0192
	g / s		.0049	.4346	.1305
1	47.88	0.89	0.0269	2.2980	0.0042
1	50.17	0.84	0.0416	3.7940	0.0053
1	54.1	0.83	0.0530	5.2280	0.0078
1	57.49	0.83	0.0515	3.6600	0.0402
0		1.02	0.0341	0.2984	0.0915
0		1.15	0.0181	0.2107	0.1212
0		1.14	0.0096	0.1878	0.1017
0		1.06	0.0046	0.2334	0.0467
0		1.00	0.0036	0.1401	0.0289
0		0.97	0.0024	0.0828	0.0121
0		0.97	0.0017	0.0573	0.0055
0		0.96		0.0742	0.0032
0		0.95		0.0612	0.0025
0		0.95		0.0484	
0		0.97		0.0397	
0		0.97		0.0318	
0		0.95		0.0231	
0		0.92		0.0150	
	Sum		.2471	16.4839	.4708
	Minus Baseline		.0098	.1666	.0144
	g / s		.0593	4.0793	.1141

Analysis of Rich Open Loop Emission Rates During Warm Start Bag of UCLA Acceleration Cycle (continued)

Open loop	Speed	Lambda	HC	CO	NOx
1 = open loop	mph		g/s	g/s	g/s
1	52.09	0.87	0.0145	0.0225	0.0030
1	53.53	0.83	0.0230	2.1010	0.0054
1	57.31	0.83	0.0277	3.8410	0.0348
0		1.02	0.0201	3.2580	0.0908
0		1.15	0.0083	1.6000	0.1195
0		1.12	0.0053	0.5752	0.0675
0		1.05	0.0033	0.2190	0.0309
0		0.99	0.0022	0.1011	0.0124
0		0.97	0.0016	0.0618	0.0072
0		0.97		0.0667	0.0058
0		0.97		0.0633	0.0044
0		0.97		0.0369	0.0032
0		0.89		0.0243	0.0020
0		0.89		0.0157	
	Sum		.1060	11.9865	.3869
	Minus Baseline		.0084	.1309	.0160
	g / s		.0325	3.9519	.1236

A.6.4 Summary of the Analysis of Rich Open Loop Emission Rates by Speed of the UCLA Acceleration Cycle

30 - 40 mph				40 - 50 mph				50 - 60 mph			
Speed	HC	CO	NOx	Speed	HC	CO	NOx	Speed	HC	CO	NOx
37.40	0.0235	1.9001	0.0898	40.35	0.0810	6.3182	0.3123	50.17	0.0593	4.0793	0.1141
39.62	0.0470	6.0116	0.2546	40.93	0.0235	1.9001	0.0898	50.20	0.0312	4.6829	0.1460
				40.98	0.0229	1.6178	0.0584	50.22	0.0590	3.6385	0.0997
				41.18	0.0056	0.4752	0.0298	50.63	0.0260	3.4742	0.1186
				41.90	0.1286	4.0664	0.0787	50.83	0.0255	2.9876	0.1316
				42.87	0.0347	3.1600	0.0725	50.96	0.0238	2.9347	0.1100
				44.11	0.0810	6.3182	0.3123	51.00	0.0246	2.8811	0.0784
				44.38	0.0255	2.9876	0.1316	51.12	0.0329	4.1593	0.1149
				44.88	0.0261	3.5039	0.1264	51.12	0.0508	6.2647	0.1850
				44.90	0.0235	1.9001	0.0898	51.18	0.0344	4.6088	0.1422
				45.06	0.0056	0.4752	0.0298	51.21	0.0209	3.4531	0.0623
				45.13	0.0229	1.6178	0.0584	51.27	0.0272	4.1584	0.0646
				45.43	0.0049	0.4346	0.1305	51.34	0.0212	2.7681	0.0331
				45.44	0.0498	3.4803	0.0301	51.72	0.0333	3.9637	0.1266
				45.49	0.0432	2.9767	0.0748	51.72	0.0312	3.5645	0.0691
				45.73	0.0117	1.5323	0.0548	51.80	0.0651	3.2097	0.0934
				45.82	0.0347	3.1600	0.0725	52.01	0.0117	1.5323	0.0548
				46.07	0.0590	3.6385	0.0997	52.09	0.0325	3.9519	0.1236
				46.09	0.1286	4.0664	0.0787	52.41	0.0209	3.4531	0.0623
				46.19	0.0212	2.7681	0.0331	52.43	0.0344	4.6088	0.1422
				46.30	0.0651	3.2097	0.0934	52.54	0.0198	2.2048	0.0058
				46.55	0.0255	2.9876	0.1316	52.64	0.0031	0.3470	0.0149
				46.96	0.0261	3.5039	0.1264	52.83	0.0364	2.9111	0.0157
				47.40	0.0260	3.4742	0.1186	52.83	0.0380	3.9601	0.6690
				47.62	0.0212	2.7681	0.0331	52.83	0.0246	2.8811	0.0784
				47.88	0.0593	4.0793	0.1141	52.85	0.0432	2.9767	0.0748
				47.94	0.0651	3.2097	0.0934	52.89	0.0498	3.4803	0.0301
				48.04	0.0272	4.1584	0.0646	53.01	0.0333	3.9637	0.1266
				48.05	0.0117	1.5323	0.0548	53.05	0.1286	4.0664	0.0787
				48.08	0.0312	3.5645	0.0691	53.08	0.0329	4.1593	0.1149
				48.42	0.0235	1.9001	0.0898	53.17	0.0347	3.1600	0.0725
				48.56	0.0049	0.4346	0.1305	53.53	0.0325	3.9519	0.1236
				48.69	0.0246	2.8811	0.0784	53.67	0.0590	3.6385	0.0997
				48.79	0.0229	1.6178	0.0584	53.89	0.0074	0.6994	0.0057
				48.80	0.0498	3.4803	0.0301	54.10	0.0593	4.0793	0.1141
				48.96	0.0031	0.3470	0.0149	54.15	0.0255	2.9876	0.1316
				49.07	0.0238	2.9347	0.1100	54.42	0.0260	3.4742	0.1186
				49.18	0.0432	2.9767	0.0748	54.77	0.0246	2.8811	0.0784
				49.64	0.1286	4.0664	0.0787	55.00	0.0238	2.9347	0.1100
				49.71	0.0380	3.9601	0.6690	55.04	0.0508	6.2647	0.1850
				49.74	0.0347	3.1600	0.0725	55.05	0.0198	2.2048	0.0058
								55.32	0.0312	3.5645	0.0691
								55.35	0.0651	3.2097	0.0934
								55.43	0.0364	2.9111	0.0157
								55.89	0.0056	0.4752	0.0298
								56.05	0.0074	0.6994	0.0057
								56.09	0.0344	4.6088	0.1422
								56.20	0.0432	2.9767	0.0748
								56.33	0.0498	3.4803	0.0301
								56.35	0.0209	3.4531	0.0623
								56.38	0.1286	4.0664	0.0787
								56.39	0.0333	3.9637	0.1266
								56.45	0.0347	3.1600	0.0725
								56.53	0.0380	3.9601	0.6690
								56.85	0.0590	3.6385	0.0997
								57.15	0.0329	4.1593	0.1149
								57.31	0.0325	3.9519	0.1236
								57.45	0.0260	3.4742	0.1186
								57.49	0.0593	4.0793	0.1141
								57.72	0.0312	3.5645	0.0691
								58.05	0.0056	0.4752	0.0298
								58.12	0.0238	2.9347	0.1100
								58.33	0.0246	2.8811	0.0784
								58.41	0.0651	3.2097	0.0934
								58.87	0.0432	2.9767	0.0748

A.7 Estimated and Measured Emission Rates For Dynamometer Driving Patterns

		HC emission rates, g/mi					CO emission rates, g/mi					NOx emission rates, g/mi				
Bag &	Distance	Load model		Accel model		Dyno	Load model		Accel model		Dyno	Load model		Accel model		Dyno
Pattern	mi	estimate	% diff	estimate	% diff	measured	estimate	% diff	estimate	% diff	measured	estimate	% diff	estimate	% diff	measured
Cold Start:	(Bag 1)															
Freeway	12.59	0.3437	22.9	0.3281	27.5	0.4325	4.1984	-129.5	3.8991	-125.1	0.8985	0.3061	-111.3	0.3050	-111.0	0.0872
Urban	7.49	0.5290	3.7	0.5077	7.8	0.5489	2.8936	28.2	2.8092	31.1	3.8418	0.2138	-12.5	0.2050	-8.3	0.1886
Acceleration	10.97	0.2753	65.5	0.2357	79.0	0.5435	8.0367	50.6	7.0173	63.1	13.4874	0.4089	13.9	0.2843	49.2	0.4699
FTP	3.50	0.5871	22.5	0.5363	31.4	0.7360	5.2941	14.4	5.3288	13.8	6.1187	0.3052	-15.6	0.2905	-10.7	0.2609
FTP - Adjusted	7.26	0.3715	5.5	0.3577	9.3	0.3925	3.1813	2.8	3.2710	0.0	3.2715	0.1949	-27.5	0.2025	-31.2	0.1478
Hot Running:	(Bag 2)															
Freeway	12.51	0.1009	-96.9	0.1135	-105.7	0.0350	2.1716	-166.4	3.1101	-175.9	0.1992	0.2503	-29.1	0.3037	-47.7	0.1868
Urban	7.48	0.1646	-62.8	0.1635	-62.2	0.0859	1.2690	-84.1	1.2855	-85.2	0.5175	0.1760	2.6	0.1984	-9.4	0.1806
Acceleration	10.90	0.1913	12.4	0.1723	22.7	0.2165	6.9685	37.7	5.8484	54.3	10.2033	0.3958	19.3	0.2775	53.5	0.4803
FTP	3.76	0.1708	-80.6	0.1914	-89.9	0.0727	1.2146	-64.7	1.3555	-74.3	0.6211	0.0922	-73.7	0.1206	-95.7	0.0425
HFET	9.98	0.0676	-91.5	0.0818	-105.8	0.0252	1.5827	-184.1	2.0640	-187.7	0.0657	0.2467	22.3	0.3063	0.8	0.3087
Warm Start:	(Bag 3)															
Freeway	12.49	0.1186	-64.9	0.1566	-88.5	0.0605	2.8148	-122.3	3.5308	-135.5	0.6788	0.2642	-8.4	0.3106	-24.5	0.2429
Urban	7.45	0.1755	-37.9	0.2012	-50.8	0.1196	1.6125	1.9	1.7617	-7.0	1.6432	0.1734	25.5	0.1933	14.7	0.2240
Acceleration	10.89	0.2073	0.1	0.2040	1.7	0.2075	7.6801	41.8	6.9251	51.6	11.7418	0.3753	31.2	0.2789	59.3	0.5139
FTP	3.50	0.1349	-62.7	0.1780	-86.5	0.0705	2.0650	-146.2	2.7342	-158.0	0.3209	0.2285	29.6	0.2648	15.0	0.3078
FTP - Adjusted	7.26	0.1535	-72.7	0.1849	-88.3	0.0717	1.6246	-109.3	2.0201	-123.7	0.4764	0.1579	7.6	0.1901	-10.9	0.1704
FTP Weighting:	((Bag1*0.43)+(Bag 2) + (Bag 3*0.57))/2															
Freeway	12.53	0.1581	-21.3	0.1719	-29.5	0.1278	2.7907	-140.6	3.3996	-149.9	0.4862	0.2663	-37.9	0.3059	-51.1	0.1814
Urban	7.47	0.2461	-23.1	0.2482	-24.0	0.1951	1.7162	-10.0	1.7488	-11.9	1.5530	0.1834	6.0	0.1984	-1.9	0.1947
Freeway/Urban Average	10.00	0.2021	-22.4	0.2101	-26.2	0.1614	2.2534	-75.4	2.5742	-86.5	1.0196	0.2248	-17.8	0.2522	-29.1	0.1880
Acceleration	10.92	0.2139	28.2	0.1950	37.3	0.2842	7.4010	42.1	6.4066	55.7	11.3478	0.3928	21.5	0.2794	54.3	0.4876
FTP	3.59	0.2501	-15.2	0.2617	-19.7	0.2147	2.3340	-30.4	2.6027	-41.0	1.7175	0.1768	-6.9	0.1982	-18.2	0.1651
FTP - Adjusted	7.26	0.2090	-38.8	0.2253	-45.9	0.1412	1.7543	-41.6	1.9567	-52.0	1.1497	0.1330	-26.7	0.1580	-43.4	0.1016
1989-92 Standard	-	0.4100	-	0.4100	-	0.4100	7.0000	-	7.0000	-	7.0000	0.4000	-	0.4000	-	0.4000
Error Analysis:	Note: No adjusted or weighted data included, only originally collected data (bags 1, 2 and 3).															
Average % Difference			-28.5		-32.3			-55.6		-56.5			-8.2		-8.8	
Standard Deviation			52.2		62.7			87.8		94.5			42.7		52.3	

A.8 Estimated Emission Rates For On-Road Driving Patterns

A.8.1 Estimated Emission Rates For Conservative Driving On-Road Patterns With a Cold Start Added

Route Number Dir, Expt#	Emission rates by Load modes (g/mi) HC	CO	NOx	Emission rates by Acceleration modes (g/mi) HC	CO	NOx	Percent difference between methods HC	CO	NOx
Freeway Routes									
1-NS-36	0.5306	4.8864	0.2593	0.5021	5.2822	0.2912	-5.68	7.49	10.95
1-SN-37	0.4235	4.2983	0.2792	0.4026	4.9097	0.3288	-5.19	12.45	15.09
2-NS-40	0.3530	4.5468	0.3479	0.3517	5.9246	0.3860	-0.37	23.26	9.87
2-SN-41	0.6017	4.7449	0.2424	0.5596	5.2564	0.2676	-7.52	9.73	9.42
3-NS-38	0.5983	4.0796	0.1885	0.5525	4.2184	0.2010	-8.29	3.29	6.22
3-SN-39	0.5782	3.9321	0.1857	0.5410	3.9733	0.2150	-6.88	1.04	13.63
4-SN-17	0.5106	4.4764	0.2682	0.4696	4.4811	0.2655	-8.73	0.10	-1.02
4-NS-18	0.3239	5.7575	0.4282	0.3312	7.1998	0.4639	2.20	20.03	7.70
5-SN-25	0.5465	3.7577	0.1847	0.5115	3.7978	0.2167	-6.84	1.06	14.77
5-NS-26	0.3482	4.6827	0.3437	0.3489	6.8925	0.4357	0.20	32.06	21.12
6-SN-29	1.3155	8.3971	0.1903	1.1912	8.2017	0.1817	-10.43	-2.38	-4.73
6-NS-30	0.4100	7.3212	0.4604	0.3915	7.6636	0.4401	-4.73	4.47	-4.61
7-EW-2	0.5362	6.2201	0.3266	0.4933	6.0929	0.3114	-8.70	-2.09	-4.88
7-WE-3	0.3908	3.0041	0.2314	0.3698	3.3484	0.2717	-5.68	10.28	14.83
8-NS-13	0.3205	5.6945	0.4083	0.3308	8.6569	0.5050	3.11	34.22	19.15
8-SN-14	1.5412	9.9840	0.1663	1.4009	9.9290	0.1716	-10.01	-0.55	3.09
Freeway Averages:	0.5830	5.3615	0.2819	0.5468	5.9893	0.3096	-5.22	9.65	8.16
Freeway Std. Dev.	0.3467	1.8419	0.0943	0.3059	1.9337	0.1069	4.26	11.85	8.49
Freeway Maxima	1.5412	9.9840	0.4604	1.4009	9.9290	0.5050	3.11	34.22	21.12
Freeway Minima	0.3205	3.0041	0.1663	0.3308	3.3484	0.1716	-10.43	-2.38	-4.88
Urban Routes									
1-NS-6	0.5828	3.9968	0.2812	0.5382	3.8057	0.2612	-8.29	-5.02	-7.66
1-SN-7	0.5454	3.6771	0.2818	0.4874	3.4792	0.2353	-11.90	-5.69	-19.76
2-EW-46	0.8119	5.4364	0.1678	0.7566	5.4076	0.1789	-7.31	-0.53	6.20
2-WE-47	0.8414	5.4840	0.1970	0.7848	5.4082	0.1956	-7.21	-1.40	-0.72
3-EW-42	1.5131	11.8474	0.4082	1.3966	11.5331	0.4004	-8.34	-2.73	-1.95
3-WE-43	0.8929	5.7998	0.2194	0.8241	5.6803	0.2358	-8.35	-2.10	6.96
4-EW-21	0.7221	4.6873	0.2193	0.6791	4.7123	0.2603	-6.33	0.53	15.75
4-WE-22	5.4072	32.8659	0.5410	5.0971	32.3864	0.5356	-6.08	-1.48	-1.01
5-SN-11	0.7975	5.1616	0.2440	0.7390	5.0735	0.2337	-7.92	-1.74	-4.41
5-NS-12	1.6391	10.2646	0.2544	1.5575	10.1915	0.2748	-5.24	-0.72	7.42
6-NS-27	0.7434	4.8505	0.2110	0.6980	4.8197	0.2494	-6.50	-0.64	15.40
6-SN-28	0.8812	5.8057	0.2418	0.8210	5.6026	0.2285	-7.33	-3.63	-5.82
7-SN-50	0.5858	3.8724	0.1789	0.5427	3.8422	0.2033	-7.94	-0.79	12.00
7-NS-51	0.6353	4.1432	0.2509	0.5840	4.0729	0.2443	-8.78	-1.73	-2.70
8-EW-48	0.4332	2.8727	0.2094	0.4045	3.0012	0.2578	-7.10	4.28	18.77
8-WE-49	0.6833	5.0376	0.2517	0.6280	5.1498	0.2570	-8.81	2.18	2.06
Urban Averages:	1.1072	7.2377	0.2599	1.0337	7.1354	0.2657	-7.71	-1.32	2.53
Urban Std. Dev.	1.1913	7.2210	0.0931	1.1260	7.1083	0.0866	1.51	2.45	10.13
Urban Maxima	5.4072	32.8659	0.5410	5.0971	32.3864	0.5356	-5.24	4.28	18.77
Urban Minima	0.4332	2.8727	0.1678	0.4045	3.0012	0.1789	-11.90	-5.69	-19.76
Combined Averages:	0.8451	6.2996	0.2709	0.7902	6.5623	0.2877	-6.47	4.16	5.35
Combined Std. Dev.	0.9032	5.2707	0.0928	0.8485	5.1573	0.0983	3.39	10.09	9.63
Combined Maxima	5.4072	32.8659	0.5410	5.0971	32.3864	0.5356	3.11	34.22	21.12
Combined Minima	0.3205	2.8727	0.1663	0.3308	3.0012	0.1716	-11.90	-5.69	-19.76

A.8.2 Estimated Emission Rates For Conservative Driving On-Road Patterns With No Starts

Route Number Dir, Expt#	Emission rates by Load modes (g/mi)			Emission rates by Acceleration modes (g/mi)			Percent difference between methods		
	HC	CO	NOx	HC	CO	NOx	HC	CO	NOx
Freeway Routes									
1-NS-36	0.1271	4.6407	0.4034	0.1461	5.6664	0.4139	13.00	18.10	2.54
1-SN-37	0.1172	4.3357	0.3896	0.1229	5.1346	0.4002	4.64	15.56	2.65
2-NS-40	0.0997	2.0368	0.2537	0.1077	2.7563	0.2833	7.43	26.10	10.45
2-SN-41	0.1416	3.7918	0.3182	0.1394	4.2494	0.3187	-1.58	10.77	0.16
3-NS-38	0.1245	3.2656	0.3177	0.1386	4.5588	0.3537	10.17	28.37	10.18
3-SN-39	0.1309	2.9632	0.2797	0.1303	3.1841	0.2804	-0.46	6.94	0.25
4-SN-17	0.1419	4.2708	0.3934	0.1543	5.0757	0.3905	8.04	15.86	-0.74
4-NS-18	0.1264	3.2606	0.3206	0.1349	4.0901	0.3407	6.30	20.28	5.90
5-SN-25	0.1183	3.0922	0.3020	0.1202	3.5902	0.3116	1.58	13.87	3.08
5-NS-26	0.1108	3.4306	0.3328	0.1281	4.9083	0.3753	13.51	30.11	11.32
6-SN-29	0.1492	3.9267	0.3309	0.1559	4.3542	0.3244	4.30	9.82	-2.00
6-NS-30	0.1278	3.2080	0.2877	0.1310	3.5917	0.2970	2.44	10.68	3.13
7-EW-2	0.1343	4.4647	0.3749	0.1384	4.5715	0.3529	2.96	2.34	-6.23
7-WE-3	0.1090	2.9113	0.2960	0.1125	3.3966	0.3064	3.11	14.29	3.39
8-NS-13	0.1302	3.9070	0.3712	0.1395	4.7445	0.3789	6.67	17.65	2.03
8-SN-14	0.1384	3.7238	0.3299	0.1445	4.4527	0.3396	4.22	16.37	2.86
Freeway Averages:	0.1267	3.5768	0.3314	0.1340	4.2703	0.3417	5.40	16.07	3.06
Freeway Std. Dev.	0.0133	0.6859	0.0441	0.0136	0.7909	0.0416	4.32	7.53	4.66
Freeway Maxima	0.1492	4.6407	0.4034	0.1559	5.6664	0.4139	13.51	30.11	11.32
Freeway Minima	0.0997	2.0368	0.2537	0.1077	2.7563	0.2804	-1.58	2.34	-6.23
Urban Routes									
1-NS-6	0.1376	1.4555	0.2604	0.1261	1.5280	0.2375	-9.12	4.74	-9.64
1-SN-7	0.1431	1.1351	0.2248	0.1289	1.0519	0.2033	-11.02	-7.91	-10.58
2-EW-46	0.1399	0.9951	0.1783	0.1332	1.0260	0.1939	-5.03	3.01	8.05
2-WE-47	0.1465	1.0582	0.1864	0.1369	1.0166	0.1885	-7.01	-4.09	1.11
3-EW-42	0.1571	1.1445	0.1913	0.1482	1.1007	0.1951	-6.01	-3.98	1.95
3-WE-43	0.1647	1.1199	0.1567	0.1658	1.1368	0.1719	0.66	1.49	8.84
4-EW-21	0.1321	0.9405	0.1907	0.1296	0.9318	0.2036	-1.93	-0.93	6.34
4-WE-22	0.2059	2.0791	0.2534	0.1961	2.0953	0.2477	-5.00	0.77	-2.30
5-SN-11	0.1578	1.0771	0.2022	0.1462	0.9993	0.1945	-7.93	-7.79	-3.96
5-NS-12	0.1715	1.1021	0.1534	0.1775	1.1455	0.1739	3.38	3.79	11.79
6-NS-27	0.1406	1.5129	0.2551	0.1331	1.2826	0.2337	-5.63	-17.96	-9.16
6-SN-28	0.1441	1.9319	0.2492	0.1365	1.4834	0.2235	-5.57	-30.23	-11.50
7-SN-50	0.1245	1.0635	0.2093	0.1159	1.0767	0.2165	-7.42	1.23	3.33
7-NS-51	0.1364	0.9528	0.1964	0.1321	0.9999	0.2141	-3.26	4.71	8.27
8-EW-48	0.1232	0.9703	0.2158	0.1157	0.9936	0.2288	-6.48	2.35	5.68
8-WE-49	0.1387	0.9900	0.1856	0.1339	1.0154	0.2007	-3.58	2.50	7.52
Urban Averages:	0.1477	1.2205	0.2068	0.1410	1.1802	0.2080	-5.06	-3.02	0.98
Urban Std. Dev.	0.0204	0.3473	0.0339	0.0218	0.2985	0.0222	3.58	9.42	7.84
Urban Maxima	0.2059	2.0791	0.2604	0.1961	2.0953	0.2477	3.38	4.74	11.79
Urban Minima	0.1232	0.9405	0.1534	0.1157	0.9318	0.1719	-11.02	-30.23	-11.50
Combined Averages:	0.1372	2.3987	0.2691	0.1375	2.7253	0.2748	0.17	6.52	2.02
Combined Std. Dev.	0.0200	1.3110	0.0742	0.0182	1.6763	0.0755	6.59	12.82	6.43
Combined Maxima	0.2059	4.6407	0.4034	0.1961	5.6664	0.4139	13.51	30.11	11.79
Combined Minima	0.0997	0.9405	0.1534	0.1077	0.9318	0.1719	-11.02	-30.23	-11.50

A.8.3 Estimated Emission Rates For Conservative Driving On-Road Patterns With a Warm Start Added

Route	Emission rates			Emission rates			Percent difference		
Number	by Load modes (g/mi)			by Acceleration modes (g/mi)			between methods		
Dir. Expt#	HC	CO	NOx	HC	CO	NOx	HC	CO	NOx
Freeway Routes									
1-NS-36	0.1166	2.4067	0.2505	0.1588	3.0670	0.2838	26.57	21.53	11.73
1-SN-37	0.1100	2.4592	0.2680	0.1428	3.3232	0.3208	22.97	26.00	16.46
2-NS-40	0.1044	3.0816	0.3373	0.1459	4.6131	0.3771	28.44	33.20	10.55
2-SN-41	0.1316	1.9192	0.2184	0.1703	2.7621	0.2536	22.72	30.52	13.88
3-NS-38	0.1310	1.0973	0.1512	0.1686	1.4900	0.1725	22.30	26.36	12.35
3-SN-39	0.1216	1.0193	0.1513	0.1653	1.2988	0.1837	26.44	21.52	17.64
4-SN-17	0.1234	2.0053	0.2377	0.1518	2.2202	0.2392	18.71	9.68	0.63
4-NS-18	0.1303	4.6222	0.4226	0.1735	6.2053	0.4546	24.90	25.51	7.04
5-SN-25	0.1178	1.0322	0.1526	0.1563	1.2733	0.1780	24.63	18.94	14.27
5-NS-26	0.0943	3.0640	0.3259	0.1395	5.4570	0.4253	32.40	43.85	23.37
6-SN-29	0.2785	1.7802	0.1064	0.3439	2.1728	0.1140	19.02	18.07	6.67
6-NS-30	0.1385	5.8092	0.4543	0.1697	6.3242	0.4342	18.39	8.14	-4.63
7-EW-2	0.1367	3.5244	0.2929	0.1634	3.6236	0.2892	16.34	2.74	-1.28
7-WE-3	0.0818	1.0103	0.2126	0.1135	1.5052	0.2571	27.93	32.88	17.31
8-NS-13	0.1101	4.4970	0.4053	0.1558	7.4685	0.4952	29.33	39.79	18.15
8-SN-14	0.3261	2.1971	0.0665	0.4162	2.8765	0.0915	21.65	23.62	27.32
Freeway Averages:	0.1408	2.5953	0.2533	0.1835	3.4801	0.2856	23.92	23.90	11.97
Freeway Std. Dev.	0.0655	1.4315	0.1146	0.0793	1.9748	0.1237	4.49	11.08	8.67
Freeway Maxima	0.3261	5.8092	0.4543	0.4162	7.4685	0.4952	32.40	43.85	27.32
Freeway Minima	0.0818	1.0103	0.0665	0.1135	1.2733	0.0915	16.34	2.74	-4.63
Urban Routes									
1-NS-6	0.1250	1.0563	0.2472	0.1577	1.0999	0.2325	20.74	3.96	-6.32
1-SN-7	0.1372	1.0602	0.2507	0.1529	1.0803	0.2090	10.27	1.86	-19.95
2-EW-46	0.1713	1.3473	0.1178	0.2313	1.6693	0.1498	25.94	19.29	21.36
2-WE-47	0.1850	1.3046	0.1394	0.2438	1.5804	0.1618	24.12	17.45	13.84
3-EW-42	0.4151	4.9986	0.3450	0.5127	5.3188	0.3522	19.04	6.02	2.04
3-WE-43	0.2004	1.3527	0.1674	0.2574	1.6311	0.2123	22.14	17.07	21.15
4-EW-21	0.1508	1.0378	0.1796	0.2040	1.3293	0.2216	26.08	21.93	18.95
4-WE-22	1.2171	6.0111	0.3831	1.6755	7.6920	0.3484	27.36	21.85	-9.96
5-SN-11	0.1924	1.3124	0.2256	0.2305	1.4661	0.1813	16.53	10.48	-24.43
5-NS-12	0.3475	1.9948	0.1152	0.5040	2.6270	0.1928	31.05	24.07	40.25
6-NS-27	0.1623	1.1414	0.1719	0.2132	1.3738	0.1991	23.87	16.92	13.66
6-SN-28	0.1842	0.1334	0.1840	0.2444	1.5101	0.1929	24.63	91.17	4.61
7-SN-50	0.1268	0.9864	0.1637	0.1613	1.1552	1.8620	21.39	14.61	91.21
7-NS-51	0.1429	0.9891	0.2122	0.1791	1.1966	0.2200	20.21	17.34	3.55
8-EW-48	0.0884	0.6628	0.1808	0.1204	0.9742	0.2355	26.58	31.96	23.23
8-WE-49	0.1622	1.6946	0.2176	0.2015	2.0891	0.2314	19.50	18.88	5.96
Urban Averages:	0.2505	1.6927	0.2063	0.3306	2.1121	0.3252	22.47	20.93	12.45
Urban Std. Dev.	0.2707	1.5540	0.0738	0.3756	1.8160	0.4136	4.92	20.25	26.89
Urban Maxima	1.2171	6.0111	0.3831	1.6755	7.6920	1.8620	31.05	91.17	91.21
Urban Minima	0.0884	0.1334	0.1152	0.1204	0.9742	0.1498	10.27	1.86	-24.43
Combined Averages:	0.1957	2.1440	0.2298	0.2570	2.7961	0.3054	23.19	22.41	12.21
Combined Std. Dev.	0.2016	1.5396	0.0977	0.2773	1.9914	0.3010	4.69	16.13	19.66
Combined Maxima	1.2171	6.0111	0.4543	1.6755	7.6920	1.8620	32.40	91.17	91.21
Combined Minima	0.0818	0.1334	0.0665	0.1135	0.9742	0.0915	10.27	1.86	-24.43

A.8.4 Estimated Emission Rates For Aggressive Driving On-Road Patterns With a Cold Start Added

Route Number Dir, Expt#	Emission rates by Load modes (g/mi) HC	CO	NOx	Emission rates by Acceleration modes (g/mi) HC	CO	NOx	Percent difference between methods HC	CO	NOx
Freeway Routes									
1-NS-54	0.4501	5.7517	0.3989	0.4055	5.3867	0.3126	-11.00	-6.78	-27.61
1-SN-55	0.3624	9.4053	0.5889	0.3422	8.5029	0.5060	-5.90	-10.61	-16.38
6-SN-60	0.7994	5.2387	0.2122	0.7267	5.1944	0.2201	-10.00	-0.85	3.59
6-NS-61	0.4496	7.5468	0.4572	0.4339	7.3074	0.3902	-3.62	-3.28	-17.17
Freeway Averages:	0.5154	6.9856	0.4143	0.4771	6.5979	0.3572	-7.63	-5.38	-14.39
Freeway Std. Dev.	0.1938	1.8924	0.1564	0.1708	1.5884	0.1211	3.47	4.25	13.03
Freeway Maxima	0.7994	9.4053	0.5889	0.7267	8.5029	0.5060	-3.62	-0.85	3.59
Freeway Minima	0.3624	5.2387	0.2122	0.3422	5.1944	0.2201	-11.00	-10.61	-27.61
Urban Routes									
4-EW-56	0.7922	8.4243	0.5333	0.6700	7.7093	0.3964	-18.24	-9.27	-34.54
4-WE-57	0.6964	6.8144	0.5441	0.5821	5.8817	0.3523	-19.64	-15.86	-54.44
7-SN-58	0.7698	8.2818	0.4702	0.6939	7.7388	0.3820	-10.94	-7.02	-23.09
7-NS-59	0.9966	9.1866	0.4354	0.8720	8.7535	0.3371	-14.29	-4.95	-29.16
Urban Averages:	0.8138	8.1768	0.4958	0.7045	7.5208	0.3670	-15.78	-9.27	-35.31
Urban Std. Dev.	0.1286	0.9913	0.0518	0.1216	1.1957	0.0271	3.94	4.73	13.59
Urban Maxima	0.9966	9.1866	0.5441	0.8720	8.7535	0.3964	-10.94	-4.95	-23.09
Urban Minima	0.6964	6.8144	0.4354	0.5821	5.8817	0.3371	-19.64	-15.86	-54.44
Combined Averages:	0.6646	7.5812	0.4550	0.5908	7.0593	0.3621	-11.70	-7.33	-24.85
Combined Std. Dev.	0.0461	0.6372	0.0740	0.0348	0.2777	0.0665	0.33	0.34	0.39
Combined Maxima	0.9966	9.4053	0.5889	0.8720	8.7535	0.5060	-3.62	-0.85	3.59
Combined Minima	0.3624	5.2387	0.2122	0.3422	5.1944	0.2201	-19.64	-15.86	-54.44

A.8.5 Estimated Emission Rates For Aggressive Driving On-Road Patterns With No Starts

Route Number Dir, Expt#	Emission rates by Load modes (g/mi)			Emission rates by Acceleration modes (g/mi)			Percent difference between methods		
	HC	CO	NOx	HC	CO	NOx	HC	CO	NOx
Freeway Routes									
1-NS-54	0.1842	8.6450	0.5553	0.1909	7.6282	0.4568	3.51	-13.33	-21.56
1-SN-55	0.1719	8.0638	0.5519	0.1686	6.7263	0.4442	-1.96	-19.88	-24.25
6-SN-60	0.1912	6.7853	0.4639	0.1834	5.1581	0.3562	-4.25	-31.55	-30.24
6-NS-61	0.1583	6.5100	0.4517	0.1550	5.6156	0.3757	-2.13	-15.93	-20.23
Freeway Averages:	0.1764	7.5010	0.5057	0.1745	6.2821	0.4082	-1.21	-20.17	-24.07
Freeway Std. Dev.	0.0145	1.0198	0.0556	0.0160	1.1131	0.0497	3.31	8.05	4.44
Freeway Maxima	0.1912	8.6450	0.5553	0.1909	7.6282	0.4568	3.51	-13.33	-20.23
Freeway Minima	0.1583	6.5100	0.4517	0.1550	5.1581	0.3562	-4.25	-31.55	-30.24
Urban Routes									
4-EW-56	0.2430	8.7864	0.6479	0.1871	7.1272	0.4718	-29.88	-23.28	-37.33
4-WE-57	0.2724	9.8364	0.6109	0.2261	9.2835	0.4993	-20.48	-5.96	-22.35
7-SN-58	0.2153	6.6452	0.5250	0.1725	5.8049	0.4105	-24.81	-14.48	-27.89
7-NS-59	0.2341	6.6035	0.5170	0.1902	6.2010	0.4200	-23.08	-6.49	-23.10
Urban Averages:	0.2412	7.9679	0.5752	0.1940	7.1042	0.4504	-24.56	-12.55	-27.67
Urban Std. Dev.	0.0238	1.6096	0.0645	0.0228	1.5550	0.0423	3.97	8.15	6.89
Urban Maxima	0.2724	9.8364	0.6479	0.2261	9.2835	0.4993	-20.48	-5.96	-22.35
Urban Minima	0.2153	6.6035	0.5170	0.1725	5.8049	0.4105	-29.88	-23.28	-37.33
Combined Averages:	0.2088	7.7345	0.5405	0.1842	6.6931	0.4293	-12.88	-16.36	-25.87
Combined Std. Dev.	0.0066	0.4171	0.0063	0.0048	0.3125	0.0053	0.46	0.07	1.74
Combined Maxima	0.2724	9.8364	0.6479	0.2261	9.2835	0.4993	3.51	-5.96	-20.23
Combined Minima	0.1583	6.5100	0.4517	0.1550	5.1581	0.3562	-29.88	-31.55	-37.33

A.8.6 Estimated Emission Rates For Aggressive Driving On-Road Patterns With a Warm Start Added

Route Number Dir, Expt#	Emission rates by Load modes (g/mi)			Emission rates by Acceleration modes (g/mi)			Percent difference between methods		
	HC	CO	NOx	HC	CO	NOx	HC	CO	NOx
Freeway Routes									
1-NS-54	0.1433	4.6300	0.4190	0.1510	3.9899	0.3235	5.10	-16.04	-29.52
1-SN-55	0.1496	8.0160	0.5754	0.1638	7.1713	0.4907	8.67	-11.78	-17.26
6-SN-60	0.1683	1.3186	0.1725	0.2053	1.5016	0.1941	18.02	12.19	11.13
6-NS-61	0.1713	6.1537	0.4557	0.2036	5.8544	0.3857	15.86	-5.11	-18.15
Freeway Averages:	0.1581	5.0296	0.4057	0.1809	4.6293	0.3485	11.91	-5.19	-13.45
Freeway Std. Dev.	0.0138	2.8351	0.1692	0.0277	2.4599	0.1239	6.05	12.43	17.31
Freeway Maxima	0.1713	8.0160	0.5754	0.2053	7.1713	0.4907	18.02	12.19	11.13
Freeway Minima	0.1433	1.3186	0.1725	0.1510	1.5016	0.1941	5.10	-16.04	-29.52
Urban Routes									
4-EW-56	0.2451	4.7815	0.4786	0.2228	4.6163	0.3727	-10.01	-3.58	-28.41
4-WE-57	0.2254	3.7372	0.5243	0.1894	2.9989	0.3258	-19.01	-24.62	-60.93
7-SN-58	0.2208	4.7293	0.4434	0.2421	4.4614	0.3584	8.80	-6.00	-23.72
7-NS-59	0.2923	4.6668	0.3831	0.2951	4.6130	0.2921	0.95	-1.17	-31.15
Urban Averages:	0.2459	4.4787	0.4574	0.2374	4.1724	0.3373	-4.82	-8.84	-36.05
Urban Std. Dev.	0.0327	0.4966	0.0596	0.0442	0.7857	0.0359	12.21	10.70	16.86
Urban Maxima	0.2923	4.7815	0.5243	0.2951	4.6163	0.3727	8.80	-1.17	-23.72
Urban Minima	0.2208	3.7372	0.3831	0.1894	2.9989	0.2921	-19.01	-24.62	-60.93
Combined Averages:	0.2020	4.7541	0.4315	0.2091	4.4009	0.3429	3.55	-7.01	-24.75
Combined Std. Dev.	0.0134	1.6536	0.0775	0.0117	1.1839	0.0622	4.35	1.22	0.32
Combined Maxima	0.2923	8.0160	0.5754	0.2951	7.1713	0.4907	18.02	12.19	11.13
Combined Minima	0.1433	1.3186	0.1725	0.1510	1.5016	0.1941	-19.01	-24.62	-60.93