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Emission Laboratory Correlation Study Between EPA and the Japan Automobile Manufacturers Association, Inc.

by

Richard E. Lowery

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Environmental Protection Agency
Office of Air Programs
Office of Mobile Source Air Pollution Control
Emission Control Technology Division
Procedures Development Branch
Ann Arbor, Michigan

ABSTRACT

This report presents the results of an extensive correlation study between EPA and the Japan Automobile Manufacturers Association, Inc. (JAMA). It specifically compares the test facilities of Nissan and Toyota to EPA's Ann Arbor Laboratory.

No significant differences were discovered between the Toyota and EPA laboratories. Emission levels produced by vehicles tested at both laboratories were very similar.

Significant differences in emissions levels of vehicles tested at both Nissan and EPA laboratories were experienced. Vehicle variability appeared to be a major cause of the discrepancies.

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Introduction:

Certification of motor vehicles which meet the 1975 Federal emission requirements is a very precise process, especially since these vehicles have considerably lower exhaust emissions than vehicles of previous years. Because such precision is necessary, it is essential that the EPA laboratory and laboratories of vehicle manufacturers are equivalent in terms of test equipment, procedures, and conditions. Such equivalency is necessary to produce repeatable emission results among various laboratories. This report will compare laboratory characteristics of EPA's Certification Test Site #5 and the laboratories of the member companies of the Japan Automobile Manufacturers Association, Inc. (JAMA) and infer from this comparison degrees of test site equivalency. The report will not deal with test site correlation within the participating laboratories.

Purpose:

It is the intent of this report to investigate differences relating to emission certification testing between the laboratories involved and to attempt to determine the significance of these differences.

Test Equipment:

The equipment brought to the EPA laboratory by JAMA included two vehicles, fifteen cylinders of calibration gases, a flame ionization detector (FID), a digital fuel consumption meter, and a fuel tank weigh scales apparatus to measure fuel consumption.

The two vehicles tested were a 96.9 CID 1975 Toyota Carina and a 119.1 CID 1975 Datsun 610. Both had four cylinder engines and were equipped with catalytic reactors which could easily be removed from the exhaust system, if desired.

The calibration gases, provided by JAMA, included three tanks of propane in air, three tanks of carbon monoxide in nitrogen, three tanks of carbon dioxide in nitrogen, two tanks of mixed hydrocarbons in air, and one tank of nitrogen dioxide in air. Special regulators were provided by JAMA which fit these metric-sized cylinders.

The portable FID used in the testing, which was provided by Nissan Motor Company, was a Yanaco Model EHF-1001 fueled by a hydrogen-helium mixture. The digital fuel consumption meter, provided by Toyota, was manufactured in Japan by JAM. The other auxiliary fuel consumption apparatus consisted of a balance type scale supporting a fuel can which was connected to the vehicles' fuel line. This apparatus was provided and operated by Nissan.

Sequence of Correlation Testing:

All of the test equipment brought to EPA for this correlation study was used to conduct similar tests at Toyota and/or Nissan laboratories in Japan during the month of January. After the tests at EPA were completed in mid-February, the test vehicles and equipment were returned to Japan for testing at all JAMA member laboratories. This second phase of Japanese testing was begun early in March.

Test Procedures:

This subject can best be studied by categorizing the different areas of the correlation program.

Emission Tests - Before discussing the various tests which were performed, it should be emphasized that part of the normal certification procedure was omitted, namely evaporative testing. This omission was made because evaporative results have limited utility with regard to laboratory correlation.

The emission tests which were performed can be classified as three types: (1) 1975 certification tests, (2) steady-state cruising tests, and (3) "hot-start" tests. The certification tests were conducted in accordance with the 1975 Federal Test Procedure, except with respect to evaporative measurement procedures. It should be noted, however, that the test vehicles' fuel was heated from 60°F to 84°F prior to testing, as specified in the evaporative paragraphs of the FTP.

The steady-state cruising tests consisted of a series of exhaust emission collections at constant speeds. After the test vehicle was warmed on the dynamometer, it was tested for five minutes at each of the selected steady speeds - 15, 30, 40, and 50 mph. Only enough time elapsed between speeds to change sample bags and adjust speed. A separate set of collection bags was deployed for each steady-state speed.

Each "hot-start" test was conducted upon completion of a 1975 certification test and consisted of emission measurements over the 7.5 mile LA-4 cycle. Two exhaust sample bags were used for each test, one for the 505 second "hot transient" portion of the cycle, and one for the remaining "hot stabilized" segment. To ensure that the vehicle was properly warmed for the test, an appropriate warm-up cycle was run prior to the actual "hot-start" test.

Because of requests by Toyota and Nissan, the types of tests run on the two vehicles were not exactly the same. Each vehicle underwent six valid 1975 certification tests, three with and three without the

vehicles' catalytic reactors in use. Each vehicle also underwent two series of steady-state tests while the catalyst was removed. Six "hot-start" tests were performed exclusively on the Datsun 610, one-half of which were conducted with the catalytic reactor removed.

Calibration Gas Check - The calibration gases were used to check the equivalency of various laboratories' gas analyzers. This was accomplished by testing calibration gases from the same cylinders at all laboratories on analyzers used for certification testing. At EPA, these tests were performed on Train 9. Assuming the gas concentrations in the calibration tanks remained constant with time, this test is an excellent indication of analyzer equivalency.

Fuel Consumption Checks - Two different fuel consumption measurement methods were employed by JAMA to compare results with EPA's carbon balance technique. Toyota used their digital fuel consumption meter to monitor fuel flow during all EPA testing of the Toyota Carina. The meter was connected between the vehicle's fuel pump and carburetor, and a turbine type flow transducer in the meter measured fuel flow. The mass of fuel flow was continuously monitored on the meter's digital display and the total fuel consumed was recorded at the completion of each test.

Nissan employed the classic "fuel-weigh" technique to measure fuel consumption during hot-start tests conducted on the Datsun 610. An auxiliary fuel can was used to replace the vehicle's fuel tank, and the weight of the can was recorded before and after each hot-start test. The fuel consumed was calculated from those data and then translated to vehicle miles per gallon.

FID Check - The portable FID supplied and operated by Nissan was used during all tests on the Datsun 610 to check EPA's hydrocarbon emission data. Span gases and FID fuel for the analyzer, which was operated in the dynamometer test cell, were provided by EPA. EPA technicians also provided a tap on the dilute exhaust sample line so that Nissan could continuously monitor HC levels. At the completion of each test, the Nissan FID was also used to analyze the test's sample bags after EPA technicians had completed their analysis.

Data Sources:

All data presented in this report were generated in the Japanese laboratories of Toyota and Nissan or in EPA's Ann Arbor laboratory. Emission test and calibration gas data were generated in all three laboratories. Figures for fuel consumption and FID cross-checks were derived exclusively at the EPA laboratory.

Analysis of Data:

In an attempt to lead to the desired comparison of this study, the data analysis will be presented in the following categories: (1) Emission Tests - Toyota vs. EPA, (2) Emission Tests - Nissan vs. EPA, (3) Calibration Gases, (4) Fuel consumption, and (5) FID check.

Emission Tests - Toyota vs. EPA - Two types of emission tests were used to compare the Toyota and EPA laboratories - 1975 Certification Tests and steady-state tests. Data generated from these tests can be found in Appendix I.

Comparing average emission values of Certification Tests on three vehicle types (Toyota Carina, without catalyzer; Toyota Carina, with Catalyzer; Datsun 610 with Catalyzer), one discovers only two significant discrepancies. The CO value measured by EPA on the Toyota Carina, with catalyzer, was 23.8% lower than the value determined by Toyota. The HC level measured on the Datsun 610, with catalyzer, was 22.4% higher at EPA than at Toyota. Of the other ten comparative points, EPA and Toyota agreed within 3% in nine cases.

The steady-state test comparison reveals larger deviations between the two labs. EPA reported generally higher emissions at speeds of 15 and 40 mph, while Toyota's values were generally greater at 30 and 50 mph. Discrepancies were the largest at 30 mph, where EPA's HC value was 73.5% lower than that of Toyota's.

Emission Tests - Nissan vs. EPA - Three types of emission tests were used to compare these laboratories - 1975 certification tests, two phase hot-start tests, and steady-state tests. Data of these tests are presented in Appendix I.

Differences in average emission levels of the Datsun 610 between laboratories were similar for all certification and hot-start tests. EPA's HC values ranged 18-34% higher than Nissan's, while CO values revealed large discrepancies between labs, EPA levels being 47-141% higher. Nissan produced higher NO_X levels on the vehicle (10-20%), but CO_2 emissions differed by less than 2%.

Use of the Toyota Carina as a comparator of these labs shows much smaller differences in emission levels. Average emissions of that vehicle, catalyzer equipped, showed EPA 44.1% higher on HC, only 9.5% higher on CO, and only 5.3% lower on NO_X. CO_2 again was comparable, EPA being 2.4% higher.

experienced at Nissan's Japanese laboratory. There are several possible reasons for the discrepancies. (1) Most of the data comparisons presented in this report are based on vehicle emission tests. Unfortunately, vehicles are never repeatable enough to be a good source of comparison, and in this program, that fact is especially evident. When the Datsun 610 is used to compare EPA and Nissan test sites, EPA levels are approximately 30% higher for HC, 90% higher for CO, and 15% lower for NO_x. However, when the Toyota Carina is used for comparison, EPA is 44% higher than Nissan on HC, about 10% higher on CO, and only about 5% lower on NO_x. Depending upon the vehicle used for comparison, one reaches different conclusions about the degree of test site equivalency. This inconsistency is not only a major source of correlation discrepencies, but it also lowers confidence in any correlation based on vehicle emission testing. (2) Barometric pressures recorded at the two laboratories were in significantly different ranges. Nissan's facility, which is located near sea level, experienced barometric pressure averaging 760 mm of mercury during testing, while EPA's readings averaged about 740 mm. The significance of this pressure difference cannot be determined from the available data, but it could possibly be of major importance. (3) Differences in dynamometer characteristics between the test sites could be an important factor, but the tests used in this correlation were not conclusive in that regard.

As was previously discussed, the conclusions of this correlation study differ depending upon which vehicle is used as the comparator. There is a possible reason why the vehicles produced such different conclusions. Before the Toyota Carina was delivered to EPA for testing, it was completely checked by Toyota technicians at their Ann Arbor laboratory. As a result, the Toyota vehicle was probably in excellent condition before the correlation tests. On the other hand, the Datsun 610 was delivered directly from Detroit Metropolitan Airport to EPA without a careful check of its operating conditions. Thus the chances of the Datsun operating differently at EPA than it did in Japan were very good. Without a careful check of the vehicle's operation before testing, the results of the emission test correlation could have been very misleading.

The results of the fuel consumption checks performed by Toyota and Nissan also require further investigation. Nissan's mileage figures, which averaged about 3% lower than corresponding EPA numbers, were within the accuracy of a fuel weigh versus carbon balance comparison. However, Toyota's fuel meter produced miles per gallon numbers which averaged 7% lower than EPA's corresponding values. The probable reason for this discrepancy can be seen by studying the Toyota data in Appendix III. Comparing tests conducted on the first two days of the study (all steady-state tests and certification tests 1 and 2 on the Carina, without catalyzer) reveals a constant difference in Toyota's values between the two days. In all five comparisons Toyota's mileage numbers from the first test are 89-93% of the second test values. This seems to

Steady-state tests on the Datsun 610 tended to confirm emission level differences experienced in the other tests. HC values were generally higher at EPA (maximum 14.8%), CO was also slightly higher, and NO_x was considerably lower (21.8% maximum). However, CO_2 values, which were approximately the same for the other tests, were consistently lower (10-16%) at EPA for the steady-state tests.

Calibration Gases - The analysis of JAMA calibration gases on EPA's Train 9 produced data very similar to that generated at the Toyota and Nissan laboratories. (See Appendix II) The only large discrepancy in readings was EPA's naming of the cylinder containing NO_2 in air, which could be expected because of the instability of that mixture. Of the other 14 gases analyzed, Toyota values were within 2.0 percent of EPA values in 11 cases, with the largest deviation being 4.0 percent. Nissan's values were within 3.0 percent in 11 cases, with a maximum discrepancy of 4.9 percent.

Fuel Consumption - Both auxiliary fuel consumption measurement methods employed during the JAMA tests yielded lower miles per gallon numbers than EPA's carbon balance method. For the six '75 certification tests performed on the Toyota Carina, Toyota's fuel meter figures were an average of 7.2% lower than EPA's calculated values. Toyota's figures were an average of 6.6% lower on two series of steady-state tests on that same vehicle. For the five hot-start tests on the Datsun 610 used in the comparison, EPA's mileage numbers were an average of 3.2% greater than those calculated by Nissan's fuel weigh. A complete data comparison may be found in Appendix III.

FID Check - During emission testing of the Datsun 610, Nissan technicians correlated their FID by analyzing sample bags upon completion of EPA's analysis. A comparison of HC values of 33 exhaust sample bags showed EPA's values to be an average of 0.3% lower than Nissan's. However, 32 background sample HC values determined by EPA were an average of 65.7% higher than the corresponding values derived by Nissan. Complete FID comparison data may be found in Appendix IV.

Discussion:

The correlation between the test sites of Toyota and EPA was generally good. The only significant difference which could be seen was the comparative emission levels of the Carina at Steady-state speed of 30 mph, the cause of which is unclear. However, vehicle emission levels on the 1975 certification test cycle were very comparable. Consequently, whatever differences did exist between test sites was of minor significance in correlating certification emission levels.

The comparison between EPA and Nissan did not produce such a good correlation. In general, EPA emission values were higher than those

indicate an error in calibration of the Toyota flow-meter. This would also explain the large day to day variations, (3-15%) in EPA - Toyota mileage figures.

Conclusions:

Results of exhaust emission tests at Toyota and EPA facilities indicate a high degree of test site equivalency. No major differences which would affect emission certification testing could be discovered.

A comparison of results at Nissan and EPA laboratories provides some indication of possible differences. Nissan's HC emission levels were consistently lower than EPA's regardless of test vehicle or type of test. EPA's measurements of lower NO_X and much higher CO than Nissan are expected to be a result, for the most part, of test vehicle inconsistencies. Whatever differences between the laboratories which do exist were difficult to isolate from the emission test data. As a result, an accurate assessment of test site equivalency cannot be made.

The most conclusive check performed during this correlation program was the calibration gas cross-check. The three laboratories involved can feel secure that no significant differences exist among their gas analysis systems.

The fuel consumption checks performed by Toyota and Nissan gave some indication of the equivalency of various techniques. The carbon balance technique produced approximately 3% higher mileage data than fuel weigh techniques, while data derived from a fuel flow-meter deviated significantly from EPA data, probably because of meter calibration problems.

Nissan's FID check verified EPA's HC analyzer and exposed differences between the calibration techniques of the two instruments.

Summary and Recommendations:

Test site equivalency of EPA and two JAMA member companies has been compared. In general, the Nissan laboratory tended to produce higher NO_X and lower CO and HC emission levels than the other two laboratories. Variability of test vehicles between test sites makes an accurate assessment of laboratory differences very difficult.

In future correlation programs, emphasis should be put on studying analyzer, CVS, and dynamometer characteristics independent of vehicle emission tests. If emission tests are used for an overall comparison, the test vehicle should be closely checked to ensure the highest possible degree of operational consistency. It would also be advantageous to use a type of test which would allow a large number of repetitions at each laboratory. Cold-start certification tests are not suitable for this application.

APPENDICES

APPENDIX I

Emission Test Data

Section	Classification
IA	Toyota Carina without Catalyzer
IB	Toyota Carina with Catalyzer
IC	Datsun 610 without Catalyzer
ID	Datsun 610 with Catalyzer

Section IA

Toyota Carina without Catalyzer

CROSS CHECK DATA (LA4 CH)

Vehicle TOYOTA CARINA System without Catalyzer

	Test Labo.	HC	CO	NO$_x$	CO_2	Fuel Consumption	Comment
Cold -Transient (g)	TOYOTA	9.98	61.55	10.80	1452		
	NISSAN						
	EPA	8.42	60.02	9.84	1383.95		
Cold -Stabilized (g)	TOYOTA	3.35	43.87	5.13	1757		
	NISSAN						
	EPA	3.48	43.96	5.35	1773.48		
Hot -Transient (g)	TOYOTA	4.20	35.16	9.80	1335		
	NISSAN						
	EPA	4.92	37.81	8.61	1298.21		
Total (g/mile)	TOYOTA	1.34	12.05	2.05	419	20.5	
	NISSAN						
	EPA	1.32	12.17	1.93	414.47	20.8	

Note

Unit Fuel Consumption mile/gal

CROSS CHECK DATA (LA4 CH)

Vehicle TOYOTA CARINA System without Catalyzer Test Labo. TOYOTA

	Test No.	HC	CO	NOx	CO_2	Fuel Consumption	Barometric Presuure	K-factor
Cold -Transient (g)	1	9.83	64.64	10.53	1441			
	2	9.38	59.32	10.85	1451			
	3	10.73	60.68	11.02	1463			
Cold -Stabilized (g)	1	3.10	40.40	5.30	1723			
	2	3.43	43.46	5.46	1702			
	3	3.51	47.74	4.64	1786			
Hot -Transient (g)	1	3.88	33.12	9.71	1309			
	2	4.27	35.08	9.81	1334			
	3	4.46	37.29	9.88	1362			
Total (g/mile)	1	1.27	11.61	2.05	412	20.8	735.6	0.975
	2	1.32	11.86	2.09	420	20.5	741.2	0.993
	3	1.42	12.68	2.00	426	20.2	740.9	1.095

Note

Unit Fuel Consumption mile/gal

Barometric Pressure mm. g

CROSS CHECK DATA (LA4 CH)

Vehicle **Toyota Carina** System **Without Catalyst** Test Labo. **EPA**

	Test No.	HC	CO	NOx	CO_2	Fuel Consumption	Barometric Pressuure	K-factor
Cold -Transient (g)	1	8.54	68.97	9.86	1394.74			
	2	8.36	52.85	9.94	1363.75			
	3	8.35	58.24	9.71	1393.36			
Cold -Stabilized (g)	1	3.33	44.14	5.46	1772.55			
	2	3.85	43.71	5.32	1743.69			
	3	3.27	44.04	5.26	1804.19			
Hot -Transient (g)	1	4.71	37.94	8.73	1282.23			
	2	4.85	36.56	8.55	1284.74			
	3	5.21	38.93	8.56	1327.65			
Total (g/mile)	1	1.29	12.7	1.96	413.75	20.8	743.5	.8615
	2	1.36	11.6	1.93	408.32	21.1	747.8	.8871
	3	1.31	12.2	1.91	421.35	20.5	741.9	.8211

" mm Hg"

CROSS CHECK DATA (CRUISING)

Vehicle TOYOTA CARINA

	Test Labo.	HC	CO	NOx	CO_2	Mainifold Vacuum	Engine rpm	Comment
15 mph (g/mile)	TOYOTA	0.400	9.10	0.444	389.6	430	1860	
	EPA	0.52	10.96	0.45	407.20			
30 mph (g/mile)	TOYOTA	0.606	5.32	1.046	257.8	433	2500	
	EPA	0.16	4.14	0.76	333.14			
40 mph (g/mile)	TOYOTA	0.560	5.40	1.437	218.4	391	2400	
	EPA	0.70	5.92	1.46	226.08			
50 mph (g/mile)	TOYOTA	0.689	6.26	2.978	240.8	355	3045	
	EPA	0.73	5.96	2.47	245.30			

Note: 15 mph 2 nd Unit Manifold Vacuum -mmHg
30 3 rd
40 Top
50 Top

CROSS CHECK DATA (CRUISING)

Vehicle Toyota Carina Test Labo. Toyota

	Test No.	HC	CO	NOx	CO_2	Mainifold Vacuum	Engine rpm	K-Factor
15 mph (g/mile)	1	0.392	8.96	0.432	378.4	429	1880	1.001
	2	0.408	9.36	0.456	400.8	431	1840	1.009
	3							
30 mph (g/mile)	1	0.682	5.50	1.020	245.8	430	2500	0.996
	2	0.530	5.12	1.072	257.8	435	2500	1.010
	3							
40 mph (g/mile)	1	0.534	5.79	1.365	210.0	392	2400	0.998
	2	0.584	5.01	1.508	226.7	390	2400	0.995
	3							
50 mph (g/mile)	1	0.604	5.47	2.696	217.2	355	3050	1.016
	2	0.774	7.06	3.260	264.4	355	3040	1.002
	3							

CROSS CHECK DATA (CRUISING)

Vehicle Toyota Carina Test Labo. EPA

	Test No.	HC	CO	NOx	CO_2	Mainifold Vacuum	Engine rpm	K-Factor
15 mph (g/mile)	1	0.58	11.93	0.43	406.50			.8339
	2	0.45	9.99	0.47	407.90			.9034
	3							
30 mph (g/mile)	1	0.17	4.44	0.74	333.59			.8339
	2	0.14	3.84	0.77	332.70			.9034
	3							
40 mph (g/mile	1	0.75	6.11	1.47	225.54			.8339
	2	0.65	5.72	1.44	226.61			.8750
	3							
50 mph (g/mile)	1	0.76	6.05	2.56	243.36			.8339
	2	0.70	5.88	2.38	247.23			.8750
	3							

Section IB

Toyota Carina with Catalyzer

CROSS CHECK DATA (LA4 CH)

Vehicle TOYOTA CARINA System with Catalyzer

	Test Labo.	HC	CO	NOx	CO_2	Fuel Consumption	Comment
Cold -Transient (g)	TOYOTA	7.42	50.22	9.93	1482		
	NISSAN	5.08	28.4	11.5	1427		
	EPA	7.10	34.28	9.99	1439.69		
Cold -Stabilized (g)	TOYOTA	1.92	16.30	5.11	1799		
	NISSAN	1.19	13.6	5.31	1803		
	EPA	1.83	13.08	5.43	1867.05		
Hot -Transient (g)	TOYOTA	2.23	15.66	9.11	1358		
	NISSAN	2.00	11.9	9.36	1326		
	EPA	2.62	13.68	8.71	1337.36		
Total (g/mile)	TOYOTA	0.85	6.24	1.94	428	20.6	
	NISSAN	0.59	4.34	2.07	423	21.2	
	EPA	0.85	4.75	1.96	433.12	20.6	

Note

Unit Fuel Consumption mile/gal

CROSS CHECK DATA (LA4 CH)

Vehicle TOYOTA CARINA System with Catalyzer Test Labo. TOYOTA

	Test No.	HC	CO	NOx	CO_2	Fuel Consumption	Barometric Presuure	K-factor
Cold -Transient (g)	1	6.63	57.05	9.53	1496			
	2	7.65	45.95	10.21	1481			
	3	7.97	47.65	10.05	1468			
Cold -Stabilized (g)	1	1.76	17.50	4.90	1811			
	2	1.92	15.68	5.20	1785			
	3	2.08	15.71	5.23	1802			
Hot -Transient (g)	1	2.19	16.84	8.93	1351			
	2	2.17	14.96	9.24	1350			
	3	2.34	15.19	9.17	1372			
Total (g/mile)	1	0.78	6.88	1.88	430	20.5	734.4	0.899
	2	0.86	5.86	1.98	426	20.7	733.4	0.992
	3	0.91	5.98	1.97	429	20.6	734.6	1.035

Note

Unit Fuel Consumption mile/gal

Barometric Pressure mmHg

CROSS CHECK DATA (LA4 CH)

Vehicle CARINA System with Catalyzer Test Lobo. Nissan

	Test No.	HC	CO	NOx	CO_2	Fuel Consumption	Barometric Presuure	K-factor
Cold -Transient (g)	1	5.21	29.56	12.00	1434		760	0.822
	2	5.37	29.83	10.27	1433		764	0.828
	3	4.66	25.95	12.09	1414		762	0.827
Cold -Stabilized (g)	1	1.19	14.35	5.47	1815		760	0.822
	2	1.16	12.97	4.82	1790		764	0.828
	3	1.22	13.36	5.64	1805		762	0.827
Hot -Transient (g)	1	2.38	13.49	9.59	1337		760	0.815
	2	1.53	10.54	8.48	1321		763	0.828
	3	2.08	11.55	10.02	1320		762	0.827
Total (g/mile)	1	0.63	4.63	2.14	426	21.0		
	2	0.57	4.24	1.87	421	21.2		
	3	0.58	4.14	2.21	422	21.3		

(mpg) (mmHg)

CROSS CHECK DATA (LA4 CH)

Vehicle Toyota Carina System With Catalyst Test Labo. EPA

	Test No.	HC	CO	NOx	CO_2	Fuel Consumption	Barometric Presuure	K-factor
Cold -Transient (g)	1	7.61	32.97	9.76	1386.73			
	2	5.75	32.39	10.70	1434.54			
	3	7.95	37.48	9.50	1497.81			
Cold -Stabilized (g)	1	1.56	12.91	5.15	1795.39			
	2	1.70	12.60	5.24	1816.31			
	3	2.23	13.73	5.91	1989.44			
Hot -Transient (g)	1	2.60	14.15	8.83	1349.65			
	2	2.47	13.34	8.93	1310.20			
	3	2.79	13.54	8.36	1352.23			
Total (g/mile)	1	0.842	4.69	1.92	421.46	21.1	741.9	.8163
	2	0.745	4.55	1.99	424.00	21.0	739.1	.8600
	3	0.97	5.0	1.97	453.90	19.7	741.2	.8095

"mm Hg"

Section IC

Datsun 610 without Catalyzer

CROSS CHECK DATA (LA4CH)

Vehicle DATSUN 610 System without Catalyzer

	Test Labo.	HC	CO	NOx	CO_2	Fuel Consumption	Comment
Cold -Transient (g)	TOYOTA						
	NISSAN	4.66	73.1	7.84	1622		
	EPA	6.81	111.63	7.42	1616.99		
Cold -Stabilized (g)	TOYOTA						
	NISSAN	4.57	37.7	6.23	1531		
	EPA	6.09	60.41	4.60	1514.04		
Hot -Transient (g)	TOYOTA						
	NISSAN	3.91	29.2	6.01	1388		
	EPA	4.90	63.92	6.30	1445.31		
Total (g/mile)	TOYOTA						
	NISSAN	1.17	11.4	1.73	402	20.6	
	EPA	1.57	19.333	1.52	404.42	19.9	

(mpg)

CROSS CHECK DATA (LA4 CH)

. Vehicle DATSUN 610 System without Catalyzer Test Labo. Nissan

	Test No.	HC	CO	NOx	CO_2	Fuel Consumption	Barometric Presuure	K-factor
Cold -Transient (g)	1	4.82	73.1	8.43	1581		761	0.836
	2	4.55	70.5	7.34	1624		756	0.819
	3	4.61	75.7	7.76	1661		759	0.818
Cold -Stabilized (g)	1	4.66	35.2	6.75	1514		761	0.836
	2	4.55	39.4	6.01	1506		756	0.819
	3	4.49	38.6	5.94	1572		759	0.818
Hot -Transient (g)	1	3.89	26.4	6.19	1367		761	0.816
	2	4.10	29.4	5.87	1385		757	0.826
	3	3.75	31.8	5.96	1413		759	0.820
Total (g/mile)	1	1.19	10.9	1.85	396	21.0	-	-
	2	1.18	11.5	1.66	399	20.7	-	-
	3	1.14	11.9	1.69	412	20.1	-	-

(mpg) (mmHg)

CROSS CHECK DATA (LA4 CH)

Vehicle **Datsun 610** System **Without Catalyzer** Test Labo. **EPA**

	Test No.	HC	CO	NOx	CO_2	Fuel Consumption	Barometric Presuure	K-factor
Cold -Transient (g)	1	9.32	128.85	7.68	1576.13			
	2	5.92	107.27	7.26	1657.72			
	3	5.18	98.78	7.31	1617.12			
Cold -Stabilized (g)	1	5.17	55.35	5.03	1470.27			
	2	7.00	62.34	4.45	1551.62			
	3	6.10	63.54	4.33	1520.22			
Hot -Transient (g)	1	4.71	46.54	6.30	1405.77			
	2	4.95	48.53	5.57	1335.62			
	3	5.05	96.70	7.02	1594.55			
Total (g/mile)	1	1.58	18.3	1.59	393.24	20.2	747.8	.9331
	2	1.65	18.2	1.43	403.43	19.9	740.2	.8272
	3	1.49	21.5	1.53	416.60	19.0	743.5	.8159

"mm Hg"

CROSS-CHECK DATA (LA-4 Hot)

Vehicle Datsun 610 System Without Catalyzer

	Test Lab	HC	CO	NO_x	CO_2	Fuel Consumption (mpg)	Barometric Pressure (mm Hg)	K-Factor
Hot Transient (g)	Nissan	2.97	27.52	5.71	1367			
	EPA	4.10	43.94	5.37	1364.02			
Hot Stabilized (g)	Nissan	4.40	34.78	5.84	1479			
	EPA	5.00	49.73	4.74	1412.93			
Total (g/mile)	Nissan	1.02	8.30	1.53	380			
	EPA	1.21	12.49	1.35	370.26			

CROSS CHECK DATA (LA4 Hot)

Vehicle Datsun 610 System Without Catalyzer Test Labo. Nissan

	Test No.	HC	CO	NOx	CO_2	Fuel Consumption	Barometric Presuure	K-factor
Hot Transient (g)	1	3.89	25.6	5.62	1299			
	2	3.07	24.6	6.07	1336			
	3	2.87	28.8	6.29	1442			
	4	3.06	31.8	5.63	1375			
Hot Stabilized (g)	1	4.69	36.1	5.49	1439			
	2	4.43	32.5	6.19	1478			
	3	4.44	37.5	6.14	1488			
	4	4.25	38.3	5.58	1496			
Total (g/mile)	1	1.14	8.22	1.48	365		30.02	0.866
	2	1.00	7.62	1.63	375		30.00	0.822
	3	0.97	8.82	1.65	391	21.5	29.80	0.823
	4	0.97	9.34	1.49	383	21.9	29.83	0.828
						mpg	in. Hg	

CROSS CHECK DATA (LA4 Hot)

Vehicle Datsun 610 System Without Catalyst Test Labo. EPA

	Test No.	HC	CO	NOx	CO_2	Fuel Consumption	Barometric Presuure	K-factor
Hot -Transient (g)	1	4.28	42.97	6.25	1437.45			
	2	3.92	44.97	4.91	1304.62			
	3	4.10	43.87	4.96	1349.98			
Hot -Stabilized (g)	1	4.97	46.21	5.28	1438.14			
	2	5.01	51.69	4.57	1371.61			
	3	5.03	51.29	4.36	1429.03			
	1							
	2							
	3							
Total (g/mile)	1	1.23	11.89	1.54	383.41		747.8	.9390
	2	1.19	12.89	1.26	356.83		739.1	.8460
	3	1.22	12.69	1.24	370.53		743.0	.8287

"mm Hg"

CROSS CHECK DATA (CRUISING)

Vehicle **DATSUN 610**

	Test Labo.	HC	CO	NOx	CO_2	Mainifold Vacuum	Engine rpm	Comment
15 mph (g/mile)	TOYOTA							
	NISSAN	0.86	3.26	0.68	307	308	1000	
	EPA	1.01	2.78	0.68	257.74			
30 mph (g/mile)	TOYOTA							
	NISSAN	0.58	7.39	1.65	279	308	1800	
	EPA	0.65	7.88	1.41	249.51			
40 mph (g/mile)	TOYOTA							
	NISSAN	0.56	3.76	0.63	343	446	2350	
	EPA	0.61	3.80	0.52	309.23			
50 mph (g/mile)	TOYOTA							
	NISSAN	0.42	4.97	1.19	361	459	2900	
	EPA	0.40	5.36	0.93	303.44			

(mmHg Abs.)(rpm)

CROSS CHECK DATA (CRUISING)

Vehicle DATSUN 610 Test Labo. Nissan

	Test No.	HC	CO	NOx	CO_2	Manifold Vacuum	Engine rpm	K-Factor
15 mph (g/mile)	1	0.92	2.88	0.69	324	302	1050	0.866
	2	0.87	3.29	0.67	296	307	1000	0.823
	3	0.80	3.60	0.67	301	314	1000	0.828
30 mph (g/mile)	1	0.58	6.02	1.75	282	297	1800	0.866
	2	0.57	8.14	1.64	274	312	1900	0.823
	3	0.60	8.02	1.56	280	314	1800	0.828
40 mph (g/mile)	1	0.63	3.51	0.62	334	437	2400	0.866
	2	0.56	3.76	0.67	353	452	2420	0.823
	3	0.50	4.02	0.60	343	449	2320	0.828
50 mph (g/mile)	1	0.46	4.60	1.18	348	447	2900	0.866
	2	0.41	5.19	1.33	385	472	2950	0.823
	3	0.38	5.11	1.07	351	459	2850	0.828

(mmHg Abs.)(rpm)

CROSS CHECK DATA (CRUISING)

Vehicle Datsun 610 Test Labo. EPA

	Test No.	HC	CO	NOx	CO_2	Mainifold Vacuum	Engine rpm	K-Factor
15 mph (g/mile)	1	1.00	3.17	0.77	257.45			.9408
	2	1.02	2.40	0.60	258.02			.8393
	3							
30 mph (g/mile)	1	0.66	8.26	1.56	255.22			.9408
	2	0.64	7.51	1.26	243.80			.8393
	3							
40 mph (g/mile	1	0.62	3.83	0.60	320.69			.9645
	2	0.60	3.77	0.45	297.77			.8393
	3							
50 mph (g/mile)	1	0.40	5.52	1.05	309.13			.9645
	2	0.39	5.19	0.81	297.75			.8393
	3							

Section ID

Datsun 610 with Catalyzer

CROSS CHECK DATA (LA4 CH)

Vehicle **DATSUN 610** System **with Catalyzer**

	Test Labo.	HC	CO	NOx	CO_2	Fuel Consumption	Comment
Cold -Transient (g)	TOYOTA	3.33	65.1	6.23	1700		
	NISSAN	2.56	27.6	7.79	1694		
	EPA	2.83	52.88	6.61	1673.31		
Cold -Stabilized (g)	TOYOTA	1.35	6.06	4.91	1551		
	NISSAN	1.34	3.05	6.20	1573		
	EPA	1.98	9.08	4.44	1517.75		
Hot -Transient (g)	TOYOTA	1.58	14.1	5.19	1462		
	NISSAN	1.86	7.81	5.75	1432		
	EPA	2.28	16.34	5.20	1410.96		
Total (g/mile)	TOYOTA	0.49	5.61	1.41	415	20.3	
	NISSAN	0.46	2.58	1.71	416	20.7	
	EPA	0.599	5.48	1.37	405.53	20.7	

(mpg)

CROSS CHECK DATA (LA4 CH)

Vehicle DATSUN 610 System with Catalyzer Test Labo. TOYOTA

	Test No.	HC	CO	NOx	CO_2	Fuel Consumption	Barometric Presuure	K-factor
Cold -Transient (g)	1	3.17	58.40	6.42	1641			
	2	3.44	71.00	6.13	1711			
	3	3.39	65.90	6.14	1749			
Cold -Stabilized (g)	1	1.36	5.66	5.03	1542			
	2	1.36	5.71	4.83	1567			
	3	1.34	6.80	4.87	1543			
Hot -Transient (g)	1	1.57	11.88	5.24	1444			
	2	1.65	15.79	5.02	1476			
	3	1.51	14.50	5.32	1465			
Total (g/mile)	1	0.48	5.01	1.44	409	20.8	732.8	1.036
	2	0.50	6.03	1.38	419	20.1	733.1	0.986
	3	0.49	5.79	1.41	417	20.1	733.9	1.023

Note

Unit Fuel Consumption mile/gal

Barometric Pressure mmHg

CROSS CHECK DATA (LA4 CH)

Vehicle DATSUN 610 System with Catalyzer Test Labo. Nissan

	Test No.	HC	CO	NOx	CO_2	Fuel Consumption	Barometric Presuure	k-factor
Cold -Transient (g)	1	2.75	29.5	8.14	1656		761	0.806
	2	2.34	22.0	7.66	1703		760	0.843
	3	2.59	31.2	7.56	1723		762	0.809
Cold -Stabilized (g)	1	1.30	2.54	6.33	1556		761	0.806
	2	1.24	3.45	6.26	1557		760	0.843
	3	1.47	3.16	6.02	1605		762	0.809
Hot -Transient (g)	1	1.94	7.58	6.31	1400		760	0.813
	2	1.78	8.38	5.44	1433		760	0.829
	3	1.86	7.47	5.49	1463		761	0.802
Total (g/mile)	1	0.48	2.60	1.79	409	21.1	-	-
	2	0.43	2.36	1.68	414	20.8	-	-
	3	0.48	2.78	1.65	424	20.3	-	-

(mpg) (mmHg)

CROSS CHECK DATA (LA4 CH)

Vehicle Datsun 610 System With Catalyzer Test Labo. EPA

	Test No.	HC	CO	NOx	CO_2	Fuel Consumption	Barometric Presuure	K-factor
Cold -Transient (g)	1	2.89	49.59	7.02	1659.82			
	2	2.65	49.88	6.40	1674.69			
	3	2.95	59.16	6.41	1685.43			
Cold -Stabilized (g)	1	1.78	8.87	4.74	1541.45			
	2	1.78	7.53	4.35	1499.59			
	3	2.37	10.85	4.22	1512.21			
Hot -Transient (g)	1	2.25	17.96	5.60	1436.66			
	2	2.23	15.76	5.02	1398.80			
	3	2.36	15.29	4.98	1397.43			
Total (g/mile)	1	0.574	5.39	1.46	409.86	20.6	737.9	.8634
	2	0.559	5.06	1.33	402.27	20.9	734.1	.8461
	3	0.665	6.00	1.31	404.46	20.7	734.8	.8445

"mm Hg"

CROSS CHECK DATA (LA-4 Hot)

Vehicle Datsun 610 System With Catalyzer

	Test Lab	HC	CO	NO_x	CO_2	Fuel Consumption (mpg)	Barometric Pressure (mm Hg)	K-Factor
Hot Transient (g)	Nissan	1.20	6.42	5.44	14.16			
	EPA	1.57	16.55	5.13	1410.58			
Hot Stabilized (g)	Nissan	1.28	3.59	5.58	15.04			
	EPA	1.66	7.22	4.70	1498.49			
Total (g/mile)	Nissan	0.33	1.33	1.46	390			
	EPA	0.43	3.21	1.31	388			

CROSS CHECK DATA (LA4 Hot)

Vehicle Datsun 610 System With Catalyst Test Labo. Datsun

	Test No.	HC	CO	NOx	CO_2	Fuel Consumption	Barometric Presuure	K-factor
Hot -Transient (g)	1	1.10	6.30	5.34	1403			
	2	1.30	6.53	5.53	1440			
	3							
Hot -Stabilized (g)	1	1.18	3.41	5.48	1496			
	2	1.39	3.77	5.69	1513			
	3							
	1							
	2							
	3							
Total (g/mile)	1	0.30	1.29	1.44	386		759.5	0.833
	2	0.36	1.37	1.49	394		760.7	0.813
	3							

"mm Hg"

CROSS CHECK DATA (LA4 Hot)

Vehicle Datsun 610 System With Catalyst Test Labo. EPA

	Test No.	HC	CO	NOx	CO_2	Fuel Consumption	Barometric Presuure	K-factor
Hot -Transient (g)	1	1.68	17.74	5.59	1454.65			
	2	1.53	17.32	4.98	1392.77			
	3	1.51	14.59	4.83	1384.33			
Hot -Stabilized (g)	1	1.56	6.84	4.70	1433.45			
	2	1.62	7.35	4.74	1545.60			
	3	1.79	7.46	4.67	1516.41			
	1							
	2							
	3							
Total (g/mile)	1	0.43	3.28	1.37	385.08		737.9	.8634
	2	0.42	3.29	1.30	391.78		734.1	.8704
	3	0.44	2.94	1.27	386.76		732.0	.8827

"mm Hg"

APPENDIX II

Calibration Gas Cross-Check

CROSS CHECK DATA (CALIBRATION GAS)

	Cylinder Number	TOYOTA	NISSAN	EPA
C_3H_8 in Air (ppmC)	2K-21938	59.1	58.6	60.0
	2K-26749	117.3	116.7	118.8
	2K-15134	184.2	184.8	182.1
CO in N_2 (ppm)	2K-20169	316	312	324.3
	2K-25154	635	629	639.7
	2K-10712	891	884	893.4
NO in N_2 (ppm)	2K-13281	64.9	66	NO_x = 62.9 NO = 62.9
	2K-20219	128	132	NO_x =126.0 NO = 126.0
	1K-90729	181	184	NO_x =181.2 NO = 181.2
CO_2 in N_2 (%)	2K-25089	0.92	0.95	.932
	2K-15250	1.79	1.80	1.806
	2K-19911	2.90	2.86	2.908
HC (mix) in Air (ppmC)	1K-9986	178	181	177.6
	K-84996	51.5	48	49.5
NO_2 in Air (ppm)	1K-48197	46.8	47.2	NO_x = 39.0 NO = 4.0

APPENDIX III

Fuel Economy Cross-Check

Fuel Economy Cross-Check

Vehicle Toyota Carina Test Lab. EPA

Certification Tests

Exhaust System	Test No.	Fuel Economy (miles/gallon)		
		Toyota Fuel Flow Meter	EPA Carbon Balance	$\frac{\text{EPA-Toyota}}{\text{EPA}}$
Without Catalyzer	1	18.2	20.8	12.5%
	2	20.3	21.1	3.8%
	3	19.6	20.5	4.4%
With Catalyzer	1	19.3	21.1	8.5%
	2	18.7	21.0	11.0%
	3	19.1	19.7	3.0%

Steady-State Tests

Cruise Speed	Test No.	Fuel Economy (miles/gallon)		
		Toyota Fuel Flow Meter	EPA Carbon Balance	$\frac{\text{EPA-Toyota}}{\text{EPA}}$
15 mph	1	17.7	20.8	14.9%
	2	19.9	20.9	4.8%
30 mph	1	22.6	26.0	13.1%
	2	25.5	26.2	2.7%
40 mph	1	32.3	37.4	13.6%
	2	36.4	37.3	2.1%
50 mph	1	31.3	34.8	10.1%
	2	33.8	34.3	1.5%

Fuel Economy Cross-Check

Vehicle Datsun 610 Test Lab. EPA

Exhaust System	Test No.	Fuel Economy (miles/gallon)		
		Nissan Fuel Tank Weigh	EPA Carbon Balance	EPA-Nissan / EPA
Without Catalyzer	1	Failure	21.9	--
	2	22.4	23.3	3.9%
	3	21.9	22.5	2.7%
With Catalyzer	1	21.6	22.7	4.8%
	2	21.8	22.3	2.2%
	3	22.1	22.6	2.2%

APPENDIX IV

FID Analyzer Cross-Check

FID CROSS CHECK DATA (LA4 CH)

Vehicle Datsun 610 System With Catalyst Test Labo. EPA

	Test No.	Exhaust Sample		Background Sample			
		EPA	EHF-1001	EPA	EHF-1001		
Cold -Transient (ppm)	1	65.10	67.0	3.60	2.6		
	2	59.10	60.0	3.60	2.6		
	3	67.80	71.2	4.80	7.4		
Cold -Stabilized (ppm)	1	25.20	25.0	3.00	3.0		
	2	25.80	25.0	3.75	2.6		
	3	33.75	36.0	4.35	7.1		
Hot -Transient (ppm)	1	51.30	54.0	3.30	3.2		
	2	51.15	52.0	3.15	2.7		
	3	54.45	56.0	4.20	5.5		

FID Description:

EPA - Beckman Model 400; Operated by EPA

EHF-1001 - Yanaco; Operated by Nissan

FID CROSS CHECK DATA (LA4 Hot)

Vehicle Datsun 610 System With Catalyzer Test Labo. EPA

	Test No.	Exhaust Sample		Background Sample			
		EPA	EHF-1001	EPA	EHF-1001		
Hot -Transient (ppm)	1	39.60	42.0	3.75	3.4		
	2	37.95	38.0	5.25	3.8		
	3	37.95	36.8	5.55	3.6		
Hot -Stabilized (ppm)	1	22.80	23.0	3.30	3.1		
	2	23.70	23.2	4.35	3.1		
	3	24.90	22.8	3.00	1.4		
	1						
	2						
	3						

FID Description:

EPA - Beckman Model 400; Operated by EPA

EHF-1001 - Yanaco; Operated by Nissan

FID CROSS CHECK DATA (LA4 CH)

Vehicle Datsun 610 System Without Catalyzer Test Labo. EPA

	Test No.	Exhaust Sample		Background Sample			
		EPA	EHF-1001	EPA	EHF-1001		
Cold -Transient (ppm)	1	198.60	--	4.20	--		
	2	124.20	125	3.60	3.5		
	3	113.40	--	--	--		
Cold -Stabilized (ppm)	1	67.20	--	3.45	--		
	2	90.60	92.0	3.60	2.4		
	3	78.60	83.5	3.5	2.0		
Hot -Transient (ppm)	1	102.60	--	3.60	--		
	2	110.40	112	3.90	1.4		
	3	110.40	112	3.45	2.8		

FID Description:

EPA - Beckman Model 400; Operated by EPA

EHF-1001 - Yanaco, Operated by Nissan

FID CROSS CHECK DATA (LA4 Hot)

Vehicle Datsun 610 System Without Catalyzer Test Labo. EPA

	Test No.	Exhaust Sample		Background Sample			
		EPA	EHF-1001	EPA	EHF-1001		
Hot Transient (ppm)	1	93.90	--	3.60	--		
	2	86.70	87.8	2.70	2.0		
	3	90.60	91.0	3.00	2.6		
Hot Stabilized (ppm)	1	65.10	65.0	3.90	2.3		
	2	65.85	67.0	3.60	1.2		
	3	66.00	67.0	3.60	2.7		
	1						
	2						
	3						

FID Description:

EPA - Beckman Model 400; Operated by EPA

EHF-1001 - Yanaco, Operated by Nissan

FID CROSS-CHECK DATA

Vehicle Datsun 610 Test Lab. EPA

STEADY-STATE TESTS

Cruise Speed	Test No.	Exhaust Sample		Background Sample	
		EPA	EHF-1001	EPA	EHF-1001
15 mph	1	49.05	51.0	4.80	2.8
	2	53.40	52.0	7.50	4.4
30 mph	1	61.20	60.0	3.45	1.3
	2	60.75	59.0	4.20	1.7
45 mph	1	75.90	68.0	3.60	1.0
	2	75.45	75.0	3.60	0.8
50 mph	1	63.90	64.0	4.20	2.8
	2	61.80	60.0	3.60	--

FID Description:

EPA - Beckman Model 400; Operated by EPA

EHF-1001 - Yanaco; Operated by Nissan

APPENDIX V

Supplementary Data

Supplementary Data

	Test Laboratory		
	Toyota	Nissan	EPA
Test Cell:			
Ambient Air Temp-°F (average)	74.8	78	75
Barometric Pressure-mm Hg (average)	735.5	760	741.1
Dynamometer			
Roll Spacing (inches)	17.25	17.25	17.25
Inertia Drive - Type	Belt	Belt	Direct
Test Vehicle Tire Pressure (psig)			
Toyota Carina	45	45	45
Datsun 610	--	32	32
Vehicle Soak Area Temperature-°F	77	82.4	80