Summary of ECTD Emission Laboratory Correlation Programs Fiscal Year 1974

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ABSTRACT

This report summarizes the results of ECTD 1974 laboratory correlation programs and infers conclusions relative to the state of current emission laboratory correlation.

Data are presented and analyzed which show site-to-site correlation demonstrated during ECTD programs. Regression analyses are presented which detect the effect of barometric pressure and ambient humidity on correlation results. Other factors influencing the degree of site-to-site correlation, namely dynamometer characteristics, vehicle variability, CVS accuracy, and gas analysis accuracy, are presented and discussed.

Introduction:

During fiscal year 1974 the Emission Control Technology Division (ECTD) conducted several inter-laboratory correlation programs with motor vehicle manufacturers. Results of these studies were carefully analyzed by ECTD personnel.

Purpose:

It is the intent of this report to summarize the results of ECTD 1974 correlation programs and to draw conclusions regarding the state of emission laboratory correlation.

Summary of Programs:

ECTD correlation programs were conducted between the months of January and June, 1974. Table 1 summarizes the various programs and the dates of EPA involvement in them.

Table 1

Program	Dates of EPA Participation
Japanese Automobile Manufacturers Association (JAMA)	February 4-13
Motor Vehicle Manufacturers Association (MVMA)	March 11 - May 17
Honda	March 19 - April 9
Audi-NSU	May 31

The scope of each of the above programs was vastly different. The JAMA program involved emission tests on two vehicles, dynamometer checks, and static gas exchanges. The MVMA program consisted of complete equipment diagnostic checks, static gas exchanges, and emission tests on five vehicles. The Honda program included dynamometer and CVS checks, static gas exchanges, and emission tests on four vehicles. The Audi-NSU study consisted of gas exchanges and emission tests on one vehicle.

Analysis of Results:

The results of the above programs were analyzed to determine the degree of site-to-site equivalency and the factors affecting the degree. The following sections present those analyses.

Degree of Test Site Equivalency - Appendix A presents data relating to vehicle emission correlation. Appendix A-1 summarizes the specifications of the correlation vehicles. Appendix A-2 presents vehicle HC emissions normalized to the EPA mean value. Test-to-test variability can be derived from the 95% confidence bands. These data show a large vehicle-to-vehicle variation in the degree of HC correlation. Significant differences are seen between measurements of EPA and the following laboratories: Nissan, Honda, and GMC.

Appendix A-3 summarizes the degree of CO correlation. The normalized values show significant discrepancies between EPA and (1) Nissan, and (2) Honda, while other laboratories and EPA exhibit a high degree of correlation.

Appendix A-4 presents the NOx emission correlation comparisons. The only significant discrepancies are in the comparisons of Nissan and Audi-NSU results to EPA.

Appendix A-5 shows the normalized CO_2 comparison. Significant discrepancies are shown between EPA and results from (1) Honda, (2) GMC, (3) AMC, and (4) Ford.

Effect of Barometric Pressure on Test Results - Appendix B-1 presents the results of regression analyses of barometric pressure versus emissions. It should immediately be noticed that barometric effects are highly vehicle dependent. CO emissions most consistently correlate with the barometer, only the Toyota vehicle shows no correlation. All other vehicles exhibit the tendency of increasing CO emissions for decreasing barometer. HC emissions show correlation on several vehicles, in general, HC emissions are inversely proportional to pressure. NOx correlates with the barometer in several cases, with a general increase in NOx for increasing pressure. CO_2 values correlate well with Honda and MVMA data, however the trend is inconsistent.

Effect of Humidity on Test Results - Appendix C presents regression analyses data relating ambient humidity to emission test results. In general, no correlation was found between humidity and any emission, including corrected NOx. Consequently, the current method of correcting NOx emissions for humidity was not shown to be in error.

Discussion:

Previous discussion has related barometric pressure and ambient humidity to test results. Other factors were believed to influence site-to-site correlation, and those factors will now be discussed.

1. Dynamometers - Perhaps the most pronounced variable in all correlation programs was the dynamometer. Highly different configurations of roll size, roll spacing, inertia drive system, power absorber

capacity, and vehicle restraint system were employed in various correlation programs. In addition to these physical differences, the problems of accurately calibrating the dynamometer power absorber and speed meter are significant. Consequently, the effect of various dynamometers on test results could possibly be important, however, available data cannot quantify such effects. Future correlation efforts should be centered on learning more about the influence of the dynamometer characteristics on emission test results.

2. Vehicle Variability - Changes in the test vehicles are often a significant problem in judging the results of a correlation program. Test-to-test variability is usually acceptable, except that driver influences can sometime make HC and CO repeatability poor. But site-to-site variability is a major problem, especially since many of the vehicles in question were transported thousands of miles by air to the EPA laboratory for testing. The effect of vehicle changes is unmeasurable, and thus an unknown variable in any program. Extensive preconditioning of correlation vehicles at EPA prior to testing should help minimize this problem.

3. Constant Volume Sampler (CVS) - The CVS accuracy is also a possible source of variations in test results. The small amount of correlation work investigating this area (MVMA study) showed poor results of propane injection checks on several CVS systems. Perhaps more effort needs to be expended to quantify the influence of the CVS on test results.

4. Gas Analysis System - The phase of the correlation tests which probably contributed least to correlation problems was the gas analysis phase. Exchanges of static gases with all involved laboratories produced very comparable results. However, as laboratory-to-laboratory correlation continues to improve, the area of gas analyzer calibration and maintenance cannot be ignored.

Conclusions and Recommendations:

An analysis of the results of ECTD 1974 correlation programs shows that good inter-laboratory correlation can be obtained. There are, however, several factors which may decrease the degree of laboratory-to-laboratory emission correlation. These factors include barometric pressure, dynamometer characteristics, vehicle variability, and CVS inaccuracies.

The influence of dynamometer variables on test results could be most readily determined because such influences are usually seen in NOx and CO_2 emissions, which are most repeatable. Therefore, it is recommended that future correlation studies be designed to quantify the effects of dynamometer variables on test results.

The effect of vehicle variability on correlation results is extremely difficult to quantify. Therefore, it is recommended that all correlation vehicles be carefully preconditioned in an attempt to minimize such variability.

Barometric pressure effects, like vehicle effects, are very difficult to isolate. The best method of studying these effects would be an environmental chamber, which is currently unavailable. Another way of determining barometer influences is to collect all available data on vehicles undergoing replicate tests. It is therefore recommended that EPA collect barometric pressure data on all correlation vehicles and carefully examine such data for trends in barometric effects. Such analysis must take care to eliminate the confounding effects of dynamometer differences and vehicle variability.

References

1. "Emission Laboratory Correlation Study Between EPA and the Japan Automobile Manufacturers Association, Inc.," Richard E. Lowery; EPA Report; April, 1974.

2. "Emission Laboratory Correlation Study Between EPA and Honda Motor Company, Inc.," Richard E. Lowery; EPA Report; April, 1974.

3. "Emission Laboratory Correlation Study Between EPA and Audi-NSU Auto Union," Richard E. Lowery; EPA Report; June, 1974.

4. "Emission Laboratory Correlation Study Between EPA and the Motor Vehicle Manufacturers Association of the United States, Inc.," Richard E. Lowery; EPA Report; September, 1974.

Appendix A

Vehicle Emission Correlation Data

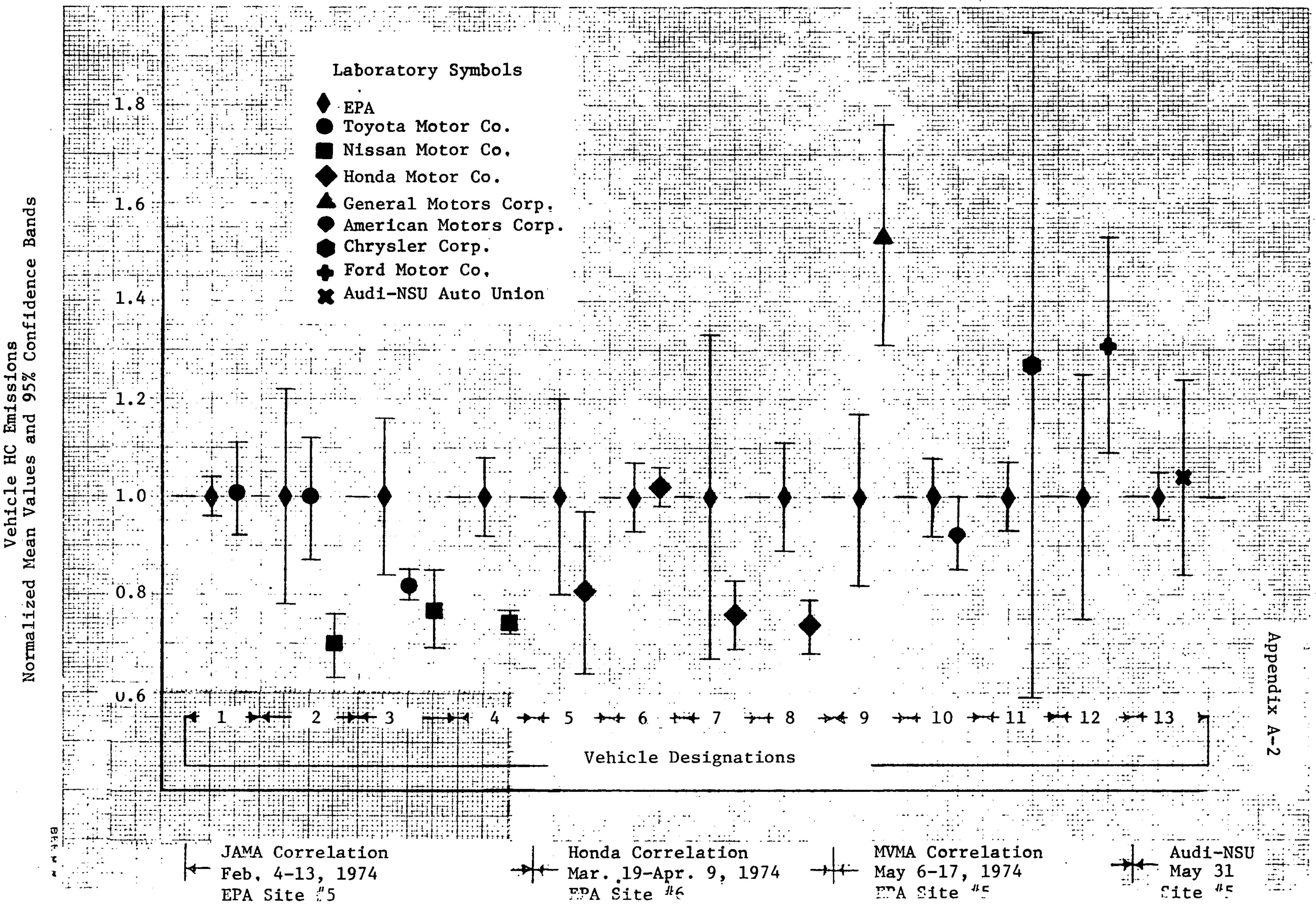
1975 Model Year Correlation Programs

Correlation Vehicle Specifications

Vehicle Designation	Manufacturer and Model	Inertia Weight	No. of Cylinders	C.I.D.	Control System
1	Toyota Carina	2500	4	96.9	Eng. Mod., Air Inj.
2	Toyota Carina	2500	4	96.9	Catalyst, EM, AI
3	Datsun 610	2750	4	119.1	EGR, Air Inj.
4	Datsun 610	2750	4	119.1	Catalyst, EGR, AI
5	Honda Civic CVCC	2000	4	90.8	Eng. Mod.
6	Honda Civic CVCC	2000	4	90.8	Eng. Mod.
7	Honda Civic	2000	4	75.5	Air Injection
8	Honda Civic CVCC	2000	4	90.8	Eng. Mod.
9	GMC Caprice	4500	8	350	Catalyst, EGR, AI
10	AMC Hornet	3000	6	232	EGR
11	Chrysler Coronet	4500	8	318	Catalyst, EM, EGR
12	Ford Maverik	4000	8	302	Catalyst
13	Audi Fox	2500	4	97	Eng. Mod.
*	GMC Repca I	4500	8	350	Eng. Mod.

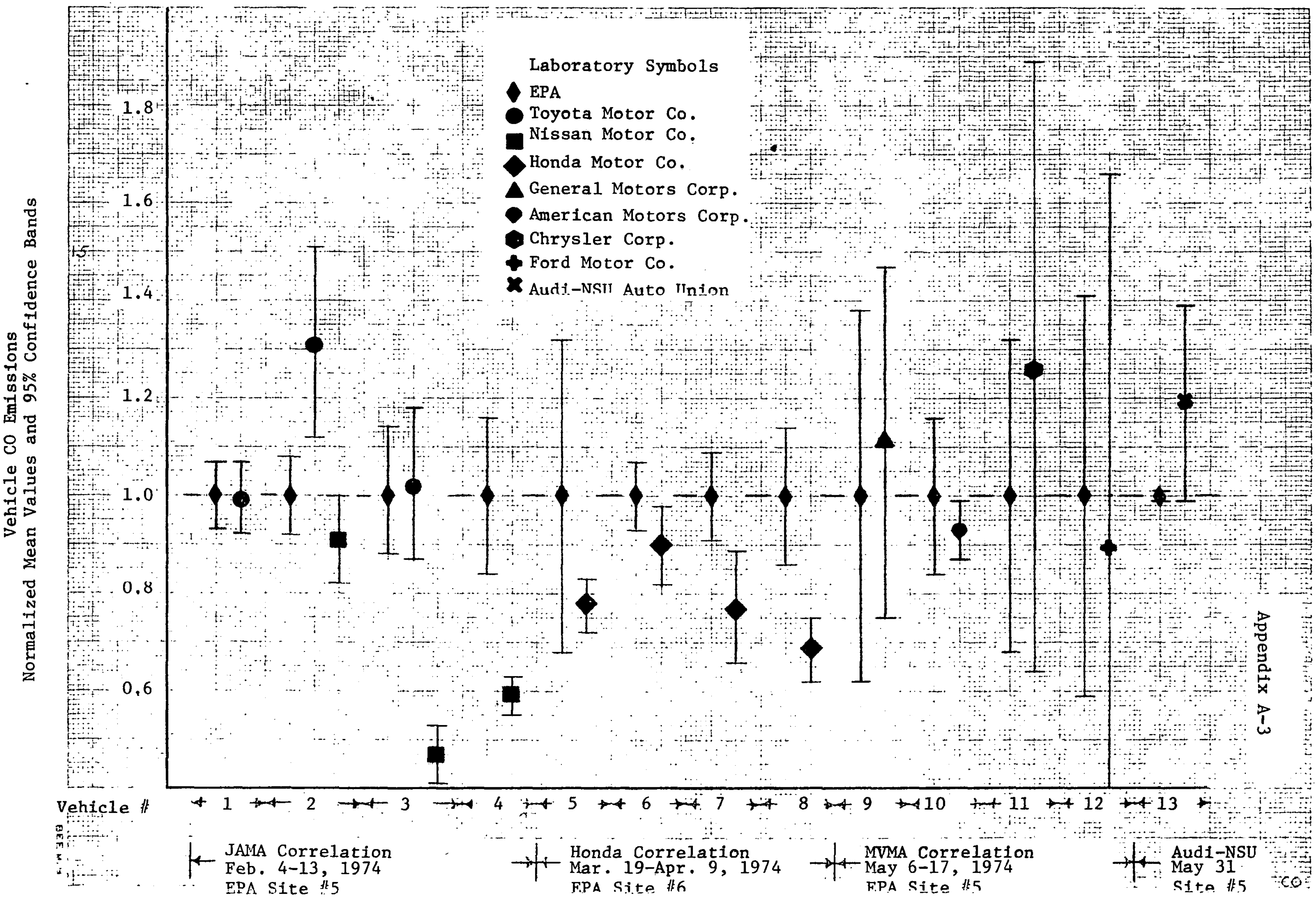
* Round-robin vehicle used in MVMA program.

1975 Model Year Correlation Programs
Vehicle HC Emissions Comparisons



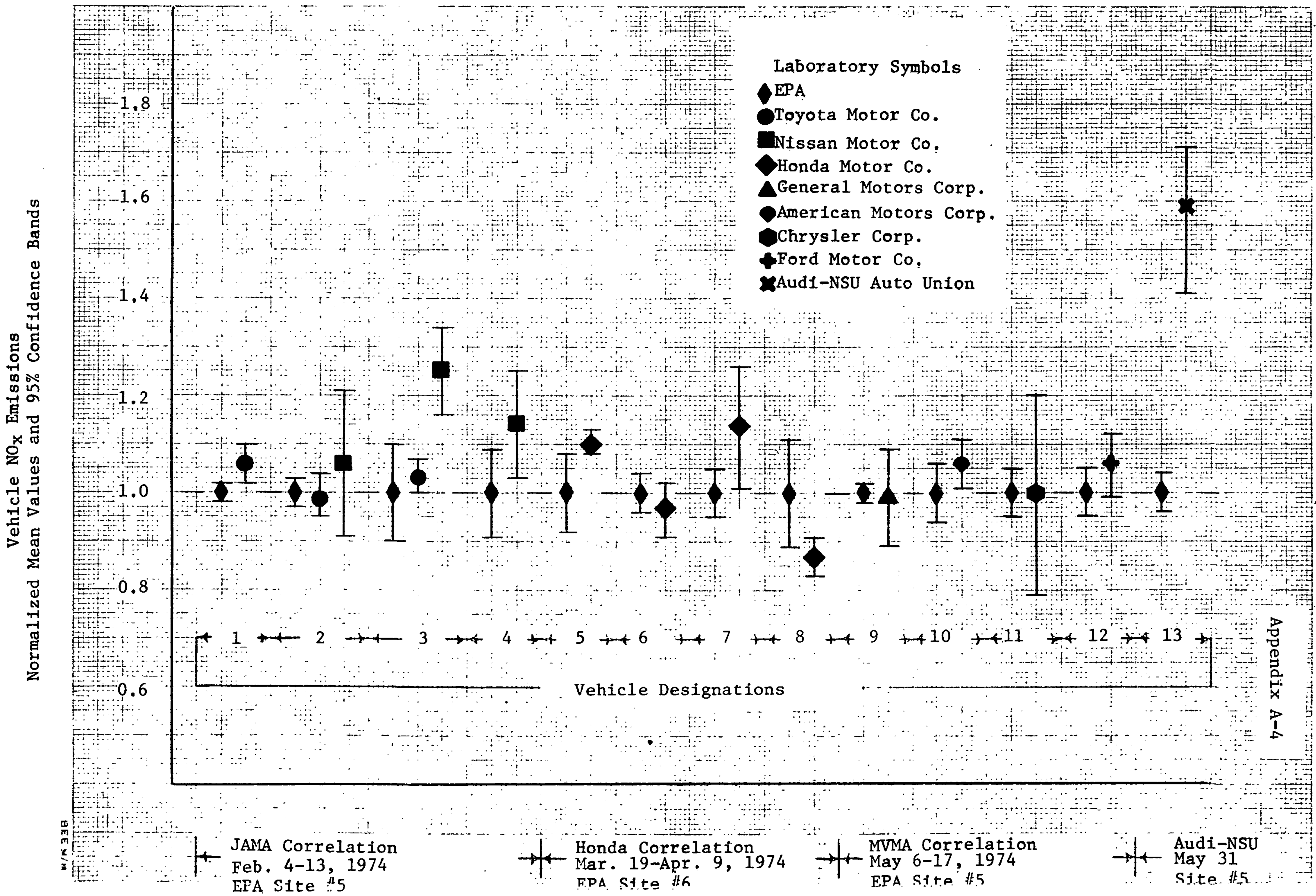
Appendix A-2

1975 Model Year Correlation Programs
Vehicle CO Emissions Comparisons



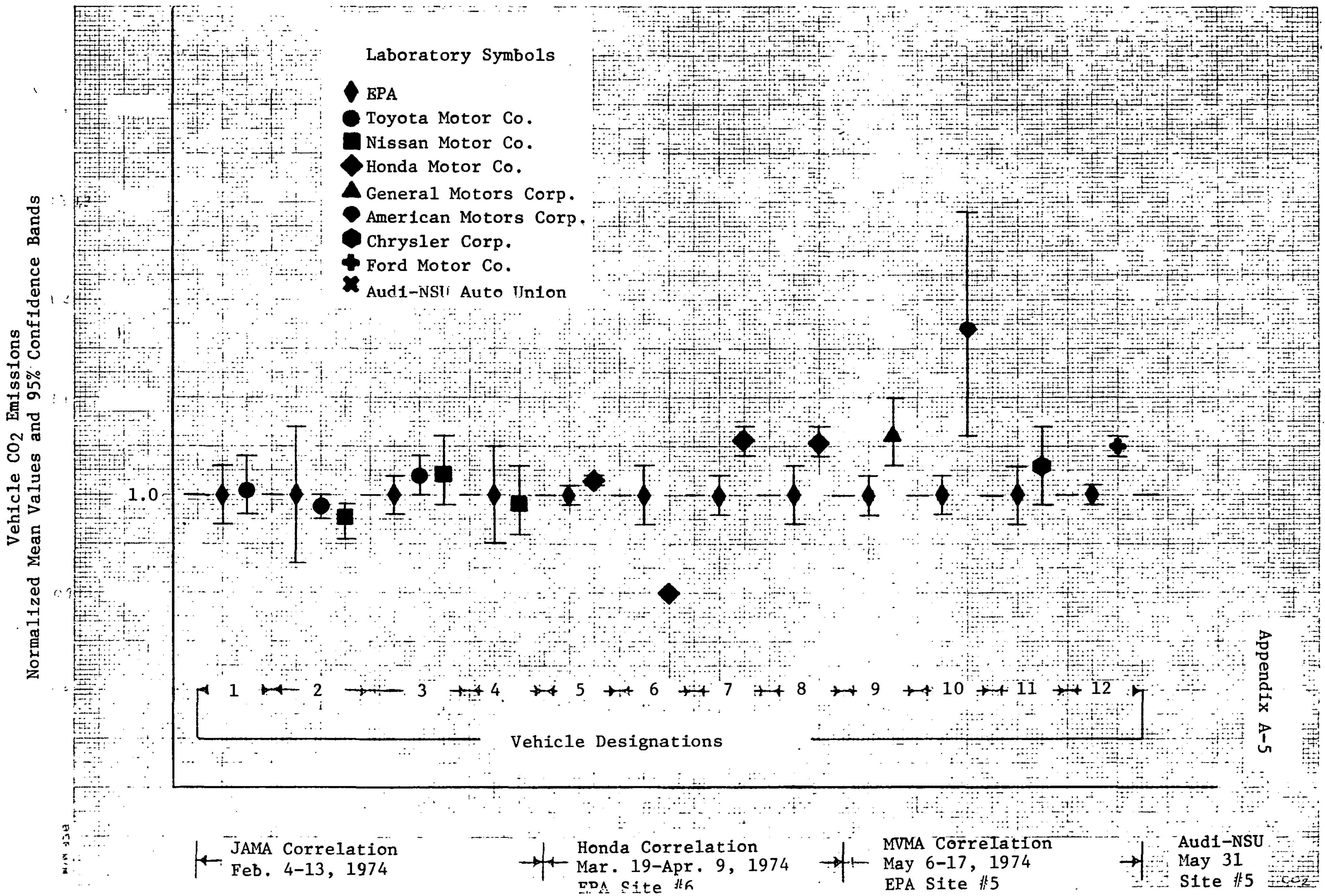
Appendix A-3

1975 Model Year Correlation Programs
Vehicle NO_x Emissions Comparisons



Appendix A-4

1975 Model Year Correlation Programs
Vehicle CO_2 Emissions Comparisons



Appendix B

Regression Analyses of Test Results vs. Barometric Pressure

Linear Regression Analyses
Test Results vs. Barometric Pressure

Regression Correlation Coefficients

Vehicle Designation*	HC	CO	NO_x	CO_2	Fuel Economy
1	.3826	.0711	-.6223	-.281	.402
2	-.847	-.782	.475	-.314	.554
3	-.937	-.909	.944	-.226	.735
4	-.524	-.960	.936	.377	.280
5	-.850	-.812	.901	.888	-.928
6	.339	-.761	-.670	-.982	+.988
7	-.583	-.965	.914	.920	-.810
8	-.933	-.959	-.682	.987	-.982
9	-.781	-.937	.654	.850	-.854
10	.416	-.422	.887	.809	-.723

* See Appendix A-1 for vehicle specifications.

Effect of +1.0 Inch of Mercury Barometric Change
Based on Least - Squares Linear Curve

Vehicle Designation	Gram/Mile Change HC	CO	NO_x	CO_2	Fuel Economy*
1	.13	.23	-.28	-12	0.8
2	-.25	-1.48	.11	-6	0.5
3	-.63	-12.02	.40	-6	1.5
4	-.07	-2.79	.30	5	0.2
5	-.08	-0.79	.12	5	-0.3
6	.01	-0.48	-.05	-28	2.4
7	-.27	-2.33	.16	13	-0.7
8	-.13	-1.54	-.16	15	-0.9
9	-.16	-1.14	.26	132	-4.2
10	.04	-0.85	.18	62	-0.6

Percent of Mean Change

	HC	CO	NO_x	CO_2	Fuel Economy
1	10.0	1.9	-14.1	-2.9	4.0
2	-32.7	-15.2	5.5	-1.4	0.0
3	-45.7	-78.1	24.7	1.6	7.5
4	-13.0	-61.2	20.2	1.2	0.1
5	-21.5	-24.1	8.6	1.4	-1.2
6	1.8	-8.7	-3.4	-8.9	8.5
7	-17.4	-21.7	10.9	4.1	-2.7
8	-22.7	-29.0	-8.4	4.2	-3.8
9	-15.9	-12.1	9.2	26.4	-24.3
10	0.8	-49.1	12.5	7.6	-6.1

* Fuel economy changes are in miles/gallon.

Appendix C

Regression Analyses of Test Results vs. Ambient Humidity

Linear Regression Analyses

Test Results vs. Ambient Humidity

Vehicle Designation*	HC	CO	NO_x	CO_2	Fuel Economy
	Regression Correlation Coefficients				
1	.5132	.0494	.7198	.4186	-.5101
2	.4427	.7079	-.2025	.6614	-.1510
3	.4404	.2500	-.0382	.2272	.1506
4	-.1718	.6145	-.5023	.1651	-.4996
9	.5000	.6162	-.2854	-.5178	.5042
10	-.7760	.2960	-.7376	-.9297	.8493

Note: NO_x results are corrected for ambient humidity per Federal Register specifications

* See Appendix A-1 for vehicle specifications.

Effect of a 10 Grain H_2O per Lb. Dry Air

Ambient Humidity Increase

Based on Least-squares Linear Curve

Gram/Mile Change

Vehicle Designation	HC	CO	NO_x	CO_2	Fuel Economy*
1	.010	.010	.021	1.2	-.067
2	.029	.313	-.011	5.0	-.035
3	.079	.891	-.004	28.1	.083
4	-.005	.402	-.036	0.5	-.076
9	.063	.889	-.063	-49.1	1.487
10	-.016	.112	-.027	-13.2	.141

Percent of Mean Change

	HC	CO	NO_x	CO_2	Fuel Economy
1	0.8	0.1	1.1	0.3	-0.3
2	3/8	6/;	-0.6	1.2	-0.2
3	5.8	5.8	-0.2	7.0	0.4
4	-1.0	8.8	-2.4	0.1	-0.4
9	6.2	9.5	-1.0	-9.8	8.9
10	-8.9	6.4	-1.3	-1.6	1.3

* Fuel economy changes are in miles/gallon.