EPA-AA-IMS/81-5

Evaluation of Applicability of the INCOLL Procedure as an I/M Strategy

November 1980

Bill Smuda

NOTICE

Technical Reports do not necessarily represent final EPA decisions or positions. They are intended to present technical analysis of issues using data which are currently available. The purpose in the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments which may form the basis for a final EPA decision, position or regulatory action.

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ABSTRACT

This report presents testing results which were gathered to investigate the suitability of using the INCOLL procedure as an emissions Inspection and Maintenance (I/M) testing procedure compared to existing I/M testing procedures. The INCOLL procedure utilizes engine and transmission inertial forces to produce pressures and temperatures in the engine that will generate significant quantities of exhaust emissions. The existing I/M test procedures utilize steady state engine operating modes to produce significant quantities of exhaust emissions. The test sequence consisted of FTP, INCOLL, LA-4 and I/M cycles. The test sequence was applied to six vehicles in various states of tune.

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1.0 INTRODUCTION.

- Testing of the INCOLL system was conducted at the EPA Motor Vehicle Emission Lab (MVEL) in Ann Arbor, Michigan during the period beginning on 29 April 1980 and ending on 13 June 1980.

- This test program was conducted at the request of Professor Lars Tn. Collin of Chalmers University of Technology, Gothenburg, Sweden. Professor Collin is the developer of the INCOLL device.

- Professor Collin along with two assistants, Ingemar Denbratt and Bo Andreasson, arrived at MVEL on 8 April 1980 to set-up the INCOLL device and develop INCOLL control parameters for the available test vehicles. They returned to Sweden on 18 April 1980. Professor Collin and assistants returned to MVEL near the end of the test program on 2 June 1980 and were available for troubleshooting until the end of testing.

2.0 INCOLL DESCRIPTION (from the developer's publications)

The INCOLL system (1, 2)* is based upon the principle that energy can be stored in the moving parts of an engine during acceleration and removed during periods of deceleration. This energy exchange provides a means of applying loads to the engine while the vehicle transmission remains in the neutral position. Because the parts involved in the inertia loads are quite accurately manufactured, the resultant loading can be well controlled and should be quite repeatable even within an engine family. Variations in the inertia characteristics of different engine families can be accommodated by reprograming the test cycle by changing settings on the control panel.

The accelerations and decelerations are accomplished through a series of step changes in the throttle setting of the engine. The throttle settings are controlled by an actuator operating the accelerator pedal or throttle linkage. The diagrams and narrative description included in the patent of the system describe the throttle position as alternating between the idle position and open positions with variable timing. The results of the variations in throttle position are further described as producing engine speeds which increase or decrease linearly with time.

As tested the INCOLL system is composed of three major components. The relationship of these components to the engine and to each other is illustrated in Figure 1. The central unit, illustrated in Figure 2, is the system "brain". The system operator (a person) sets the central unit controls prior to test initialization. The control unit settings are predetermined by the INCOLL developers; these settings are related to the inertial characteristics of the vehicle and are the same for all vehicles of that category. The central unit monitors engine speed and sends a control signal to the servo amplifier to alter engine speed. This relationship is complex and is a function of control unit settings. The control unit also has the ability to abort the test sequence if engine speed exceeds a specified value (a control unit setting), thus providing overspeed protection. When the control unit senses an overspeed condition it grounds the electrical connection at the coil and kills the engine.

The servo amplifier serves to amplify the control unit signal which will ultimately control engine speed variation. The servo amplifier also sends a signal to the control unit indicating accelerator pedal position. This signal is required to allow the control unit to fix the accelerator in a neutral position during the idle portions of the INCOLL sequence. Operator interaction with the servo amplifier is limited to adjusting the pedal adjust knob after insertion of the servo motor in the vehicle. This adjustment is necessary to zero pedal deflection caused by servo motor installation.

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* Numbers in parenthesis indicate references listed at the end of this report.

The INCOLL system also contains an exhaust sample collection sub-system. No attempt was made to utilize or evaluate this sub-system at MVEL. Several of the control unit knobs, displays and push buttons are related to this sub-system.

Normal sampling of the exhaust gases is accomplished by means of a bundle of tubes attached to a sleeve that fits over the end of the vehicle tailpipe. The exhaust gas is split between the tubes, one of which leads to the sample bag or directly to an exhaust emission analyzer. This is supposed to result in a constant fraction of the exhaust being collected and analyzed.

During testing at the Motor Vehicle Emission Lab (MVEL) the emissions generated by the INCOLL procedure were diluted, collected, and processed through MVEL CVS units. The INCOLL, FTP, and LA-4 emissions were diluted and analyzed with the same instruments following standard procedures. In order to generate a large enough dilute sample, the INCOLL device was modified to automatically repeat the cycle a number of times. Use of the CVS system over the INCOLL exhaust collection system allowed maximum flexibility to utilize available test sites.

3.0 TESTING SEQUENCE

The following test scenerio was used in this program:

a. Federal Test Procedure (FTP) (1979 procedure, non-evaporative).

b. INCOLL procedure

c. 50 mph Cruise test

d. Four-mode idle test

e. Two-mode loaded test

f. Los Angeles-4 cycle (LA-4)

g. INCOLL Procedure

h. 50 mph Cruise test

i. Four-mode Idle Test

j. Two-mode Loaded Test

Details for each of the Inspection and Maintenance (I/M) cycles are listed below:

50 Cruise Test - This is a short high speed loaded test. The dynamometer inertial weight and horsepower setting are the same as those specified for the FTP.

Four-Speed Idle Test - This short test involves four steady state idle conditions. With the transmission in neutral, emissions are measured and recorded at basic idle, idle at 2500 rpm and after return to basic idle. The transmission is then placed in drive (with the brakes applied) for sampling in the fourth mode.

Two-Mode Loaded Test - This short test consists of two operating conditions. The vehicle is operated at 30 mph and 9.0 actual horsepower with the inertial weight set 1750. Immediately following sampling in this mode, the vehicle is returned to idle mode, the transmission is placed in neutral and the emissions sampled again.

The exhaust gases generated by the I/M tests are analyzed using a garage type non-dispersive infra-red (NDIR) HC/CO analyzer.

4.0 TEST VEHICLES AND CONDITIONS.

In order to ascertain the ability of the INCOLL test procedure and the I/M test procedures to detect high emitting vehicles various malfunctions were induced in the test vehicles. A description of the test vehicles and test configurations follows:

1. 1975 Dodge Dart, 6 cylinder, 225 cubic inches, air pump, (California version).

    a. Stock.
    b. 10% misfire induced using a misfire generator.
    c. Rich idle.

2. 1977 Chevrolet Chevette, 4 cylinder, 85 cubic inches, manual transmission.

    a. Stock.
    b. Rich Idle (the LA-4 portion of this test sequence was lost due to a data handling error during testing).
    c. Vacuum leak.

3. 1980 Ford Mustang, 6 cylinder, 200 cubic inches.

    a. Stock.
    b. 10% misfire induced using a misfire generator.
    c. Rich idle (the loaded portion of the first two-mode loaded test was not accomplished due to an equipment failure).

4. 1979 Chevrolet Nova, 6 cylinder, 250 cubic inches.

    a. Stock (only the first half of this sequence was completed).

    Note: This vehicle experienced two malfunctions which delayed testing. Due to time constraints and lack of test site availability, this vehicle was removed from the test program at this point.

1) The INCOLL test cycle would get stuck in the calibration portion of the cycle, the engine would run at about 2000 rpm until the operator aborted the test. When the INCOLL personnel returned near the end of testing they quickly determined the problem to be a sticky accelerator pedal linkage (cable in sheath type). This would prevent the servo motor controller from zeroing itself. The problem was shown to be easily overcome by a simple adjustment of the pedal adjust knob on the servomotor controller.

2) While MVEL personnel in communication with INCOLL personnel in Sweden were trying to ascertain the nature of the above problem a valve lifter collapsed on two occasions during the time the cycle was stuck. The lifter pumped up on its own after a few minutes before it could be determined which lifter was failing. After the second failure a subsequent failure could not be induced either with INCOLL test or road test. The lifter failure was judged to be a vehicle problem rather than an INCOLL problem.

5. 1980 Chevrolet Citation, 4 cylinder, 2.5 liter, closed loop (California version).

a. Stock, poisoned catalytic converter.

b. Exhaust oxygen sensor disconnected, poisoned catalytic converter.

Note: The above two sequences were repeated. The INCOLL results were deleted for the first two test sequences. The INCOLL personnel determined that they had erred on the control unit settings provided to MVEL on their first visit. A new set of control unit settings were decided on by the INCOLL personnel upon their return to MVEL and the above sequences were repeated.

6. 1980 Toyota Celica Supra, 6 cylinder, 156 cubic inches, electronic fuel injection, closed loop (50 state version).

a. Stock.
b. Closed loop disabled.

5.0 TEST RESULTS

The test results are given in several attachments.

Attachment 1: Descriptions of variables and abbreviations.

Attachment 2: FTP, LA-4 and INCOLL readings. FTP and LA-4 values are in grams/mile. INCOLL values are dilute concentrations.

Attachment 3: FTP, LA-4 and four-mode idle readings.

Attachment 4: FTP, LA-4, 50 Cruise, and two-mode loaded readings. I/M test readings are raw concentrations.

Attachment 5: FTP, LA-4 and bag readings. FTP and LA-4 bag readings are dilute concentrations.

Attachment 6: FTP, LA-4 and INCOLL, all emissions. FTP and LA-4 values are grams/mile. INCOLL values are dilute concentrations.

6.0 DISCUSSION AND CONCLUSIONS

6.1 Importance of correlation

Correlation implies a mutual relationship; two quantities which can be mathematically related are said to be correlated. Also two methods of ranking objects are correlated if they put the objects in the same order or class. For example, if eggs are normally graded by weight, a method of measuring the length and girth which achieves the same result can be said to be "correlated." The degree of error which can be tolerated before "correlation" is lost is subjective.

High emitting vehicles detrimentally affect urban air quality. High emitting vehicles are considered to be those which have emissions significantly above their certification limits. If these vehicles can be identified and repaired then the quality of the air improves. Vehicle emission inspections are an effective tool in combating urban air pollution. In a periodic vehicle emission inspection a short, relatively inexpensive test is used to screen out the highest emitting vehicles that contribute the most to air pollution.

Several jurisdictions have I/M programs operating, and more will take effect over the next few years. While in many instances failure of an emission inspection is caused by improper maintenance, some failures can be attributed to the vehicle manufacturer. As an element of consumer protection, the Congress provided for an emission control performance warranty, Section 207(b) of the Clean Air Act. EPA has recently promulgated final regulations implementing this warranty, including three approved short tests. These approved short tests are similar to the short tests used in the INCOLL testing program.(3) The similarity between the INCOLL I/M short tests and the 207(b) short tests exists in the fact that for engineering evaluation purposes any 207(b) short test procedure can be assembled from the elements of the INCOLL I/M short tests. When Congress passed Section 207(b), it required that any short test used for emission control performance warranty purposes be "reasonably capable of being correlated" with the certification test, known as the Federal Test Procedure (FTP). By far the most difficult aspect of short test development is the "correlation" requirement. Trying to match the complicated, lengthy FTP with a procedure to be used for "in-use" inspections is most difficult.

EPA has adopted a correlation policy which holds false short test failures, i.e., error of commission (Ec's) to the same approximate level as if the full FTP had been used as the short test. An Ec occurs if a vehicle which would pass the FTP is failed by the short test. EPA believes that this approach satisfies the requirement of "reasonable correlation"; further, EPA emphatically rejects the contention that "perfect correlation" (i.e., prediction of numerical FTP results) is required. The limitations of FTP to FTP correlation establish a limit on the correlation that a short test can obtain. The ability of the short tests already promulgated by EPA to identify high emitting vehicles satisfies the requirement of "reasonable correlation". The short test is not equivalent to the FTP and serves an entirely different function. As adopted in the final warranty rules, it is a diagnostic tool for accurately predicting some or most of the occurrences of high emissions. It will not and need not predict with certainty the precise FTP emission levels. It is in this spirit that the INCOLL procedure and the various I/M tests were compared. The LA-4 test is included in all comparisons as a benchmark test because it is presumed to have a high degree of correlation ith the full FTP because the LA-4 is itself a portion of the full FTP.

6.2 Alternative Definitions of Correlation

Several different statistical methodologies were applied to the data obtained in this evaluation in order to describe the quality of the correlations between the FTP and the other tests.

6.2.1 Linear Regression

Linear regression analysis deals with fitting linear models to data and assessing the predictive power of linear relationships. The strength of the linear relation between the two variables being correlated can be described by the standard "Pearson product-moment correlation coefficient", denoted by "R". "R" may assume only value between 1 and -1. If there is a perfect linear relationship between the variables, then "R" will assume one of the two extreme values. If "R" is 0 (or near 0) then there is little or no tendency for the points on a corresponding scatter plot to cluster about any straight line. This does not mean that there is no relationship between the two variables being correlated, but only that this relationship (if any) is not linear.

The square of the correlation coefficient, "R^2", called "the coefficient of determination," is interpreted as the proportion of the variance in the values of the dependent variable which can be attributed to the linear relationship with the independent variable.(4)

6.2.2 Graphical

Scatter plots with a "line of best fit" representing the linear regression supplement the information conveyed by a correlation coefficient. A graphical analysis also provides a subjective "quick look" at the relationship between two variables. Finally, such a plot may be useful in helping to check on outliers or whether the assumptions which are needed for various inference procedures are met.

6.2.3 Spearman's RHO

Spearman's coefficient of rank correlation, RHO, is simply the standard product-moment correlation coefficient between the ranks of the case values of the two variables. Specifically, in the calculation of RHO, the case values of each of the two variables are ranked in order of ascending size, separately for each of the two variables. Ties are handled by assigning the average rank, then the usual correlation coefficient is computed between the two sets of ranks. The RHO coefficient has the property of assuming only values between 1 and -1. It assumes the value 1 if the two rankings are identical and the value -1 if the cases had exactly the opposite ordering under the two rankings. If RHO assumes a value of 0 (or near 0) the variables are independent. Independence of the two variables means that knowledge of the rank of one variable does not help one predict the rank assumed by the other presented in Table 1.

6.2.4 Contingency Table Analysis

Another method of illustrating the degree of correlation is a contingency table analysis. In this analysis results from a particular test are grouped into four categories:

1. Correctly Pass - Vehicle does not exceed certification standards for any emission; vehicle does not exceed short test standards for any emission.

2. Correctly Fail - Vehicle exceeds certification standards for one or more emission; vehicle exceeds short test standards for one or more emission.

3. Error of Commission - Vehicle does not exceed certification standards for any emission; vehicle exceeds short test standards for one or more emission.

4. Error of Omission - Vehicle exceeds certification standards for one or more emission; vehicle does not exceed short test standards for any emission.

A short test is considered to correlate with the FTP if it can hold Ec's to an acceptable level and identify most high emitting vehicles.(3) The percentage of high emitting vehicles identified can be controlled by varying the short test cutpoints within limits imposed by the "minimal Ec" requirement.(6) The short test effectiveness, defined as

$$\text{S.T.E.} = \frac{(\#\text{correctly failed})}{(\#\text{ correctly failed}) + (\#\text{ errors of omission})},$$

is a measure of the fraction of vehicles failing the FTP identified by the short test.

6.2.5 Percent Excess Emissions Identified

One limitation of contingency table analysis is that it regards gross failures the same as marginal failures. A measure for describing whether the failures are severe or not is percent excess emissions identified. The percent excess emissions identified is a measure of the ability of a particular test to identify emissions in excess of the certification standards. It is defined as excess emissions identified by short test failures divided by the excess emissions identified by the FTP multiplied by 100.

6.3 Correlation Results

For purposes of illustration, the tests will be grouped into three categories: LA-4 and INCOLL tests, Idle I/M tests, and Loaded I/M tests. The LA-4 test has been included in all results because it is presumed to have a high degree of correlation with the full FTP.

6.3.1 Linear Regression Results

The "coefficients of determination" (R) obtained by applying a linear regression analysis of the FTP values to the short test values are presented in Table 1.

6.3.2 Graphical Results

Figures 3 to 22 present the data obtained in this program graphically through the use of scatter plots with "lines of best fit" drawn into illustrate the relationship of the data points to the linear model.

6.3.3 Spearman's RHO Results

Spearman's RHO correlation coefficients obtained by a rank order analysis of the FTP values to the short test values are presented in Table 2.

6.3.4 Contingency Table Analysis Results

Contingency table analysis requires the use of standards to determine pass/fail status on each of the two tests being compared. For the FTP test, the certification standards were used. For the INCOLL, LA-4, and the short tests, standards were selected as described in the following paragraphs.

In order to apply contingency table analyses two different sets of short test standards suggested by the INCOLL developer (Prof. Collin) have been used. Both sets of standards have been developed from a simple linear regression analysis applied to data obtained in this program. The methods of selecting INCOLL standards differ in respect to the data utilized.

The standards obtained using method 1 (explained below) are:

1. HC-65 ppm dilute sample
2. CO-500 ppm dilute sample
3. NOx-25 ppm dilute sample

These standards represent the dilute sample concentrations corresponding to the 1977 certification limit determined by the regression line calculated from the results of the tests applied to the Dart, Chevette, and Mustang.

The standards obtained using method 2 are more complex in that the cutpoints are determined as a function of the vehicles' actual certification limit. The standards obtained using method 2 are:

	Cert Limit	INCOLL Standard
HC:	1.5	68.9
	0.9	32.6
	0.41	3.2
CO:	15.0	464.0
	9.0	252.0
	7.0	181.0
NOx:	2.0	20.9
	1.0	6.6

These stanards represent the dilute sample concentrations corresponding to the particular certification limit determined by the regression line calculated from the results of all tests.

The LA-4 standards used in the contingency analysis are the same as the certification standards, listed in Table 4.

The short test standards used in this analysis are:

1) 1.0% CO/200 ppm HC for the Four Mode Idle test.
2) 1.2% CO/220 ppm HC for the Two-Mode Loaded and 50-Cruise tests.

The certification standards for the test vehicles are listed in Table 4. The results of the contingency table analysis along with the short test effectiveness are presented in Table 3.

The detailed results of each test presented as "meets standard" (0.) or "exceeds standard" (1.0000) are given in several attachments.

Attachment 7: FTP, LA-4 and INCOLL results
Attachment 8: FTP, LA-4 and Four Mode Idle results
Attachment 9: FTP, LA-4, 50-Cruise, and Two-Mode Loaded results.

These attachments are identical in format to the numerical results to facilitate cross reference.

6.3.5 Percent Excess Emissions Identified

The percent excess emissions identified by each short test are tabulated in Table 5.

6.4 Conclusions

Of the short tests considered in this analysis (INCOLL, 4-Mode Idle, 50-Cruise and Two-Mode Loaded) the INCOLL test tends to correlate best with the FTP. The INCOLL test also identifies the highest percentage of excess emissions identified by the FTP. (See Table 5, page 42). The better identification performance of the INCOLL test is most noticeable on HC; for CO, the short tests do about as well as the INCOLL test.

During the design of the test program interest was expressed in how well the INCOLL test performed in identifying high emitting three way catalyst cars. For this reason two three-way cars, a 1980 California Citation and a 1980 Toyota Celica Supra were included in the test program. Four test sequences were performed on these two vehicles. The first of the two test sequences performed on the Toyota resulted in low emissions (well below the certification standards). There were no errors of commission by the INCOLL test or the short tests. The second test sequence performed on the Toyota resulted in extremely high emissions. The INCOLL test and the short tests all correctly failed this vehicle configuration. The two test sequences performed on the Citation resulted in marginal excess emissions. INCOLL identified the excess emissions once in four attempts. The short tests failed to identify any excess emissions. Due to this small sample and the limited experience on the INCOLL personel in optimizing inertial cycles for these vehicles no real inferences can be drawn concerning these vehicles.

This analysis only considers the effects of a single set of cutpoints in the contingency table and percent of excess emissions identified. In real world situations there are a myriad of special considerations to contend with. Different cutpoints may be selected to combat the unique air quality problems of a specific area. Areas with marginal air quality problems can achieve their air quality goals using simple idle tests. Areas with severe air quality problems may require a more sophisticated approach. An in depth analysis of the specific problem is required to determine an inspection methodology which will achieve an acceptable solution.

One shortfall of the INCOLL system as applied to I/M is that the INCOLL system as tested requires a unique inertial cycle for each engine/transmission combination. This approach is much more complicated than the presently accepted "one test for all vehicles" approach to I/M. The INCOLL approach requires that the manufacturers of the INCOLL device develop an inertial cycle for each engine/transmission combination in use at the time of adoption. Further the INCOLL approach requires that the inspection station operator correctly identify each engine/transmission combination tested. The INCOLL procedure may be more appropriate, at this time, in a situation where a large quantity of similar vehicles is being tested such as in an assembly line test or in emission factors testing. A factor which may affect the data obtained in this test program is test design. Five vehicles were tested with various induced malfunctions. The induced malfunctions are not necessarily representative of actual vehicle failures. Further, no attempt was made to account for any within vehicle correlation.

REFERENCES

1. "INCOLL - A New Technology in Emission Testing", Lars Tn Collin, June 1978, SAE 780618.

2. INCOLL Exhaust Emissions Test Procedure A Review, D. Harold Davis, EPA Emission Control Tecnology Division, October 1977.

3. Motor Vehicles; Emission Control System Performance Warranty Short Tests and Warranty Regulations; Final Rules, Federal Register, Part IX Environmental Protection Agency, May 22, 1980.

4. "An Introduction to Multivariate Statistical Analysis," T.W. Anderson John Wiley and Sons, Inc.

5. "Theory of Rank Tests", Jaroslav Hajek, Zbynek Sidak, Academic Press.

6. Light Duty Vehicle and Light Duty Truck Emission Performance Warranty; Short Tests and Standards, EPA Emission Control Technology Division, December 1979, IMS-009/ST-1.

INCOLL SYSTEM SCHEMATIC DIAGRAM

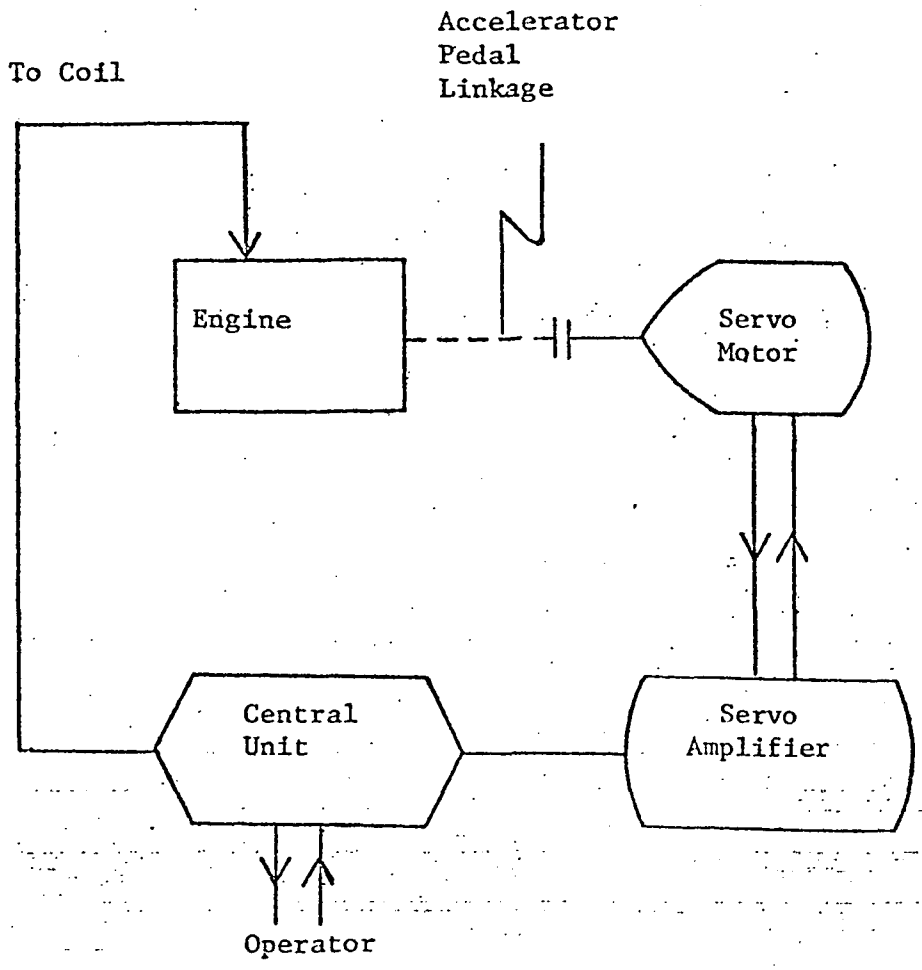
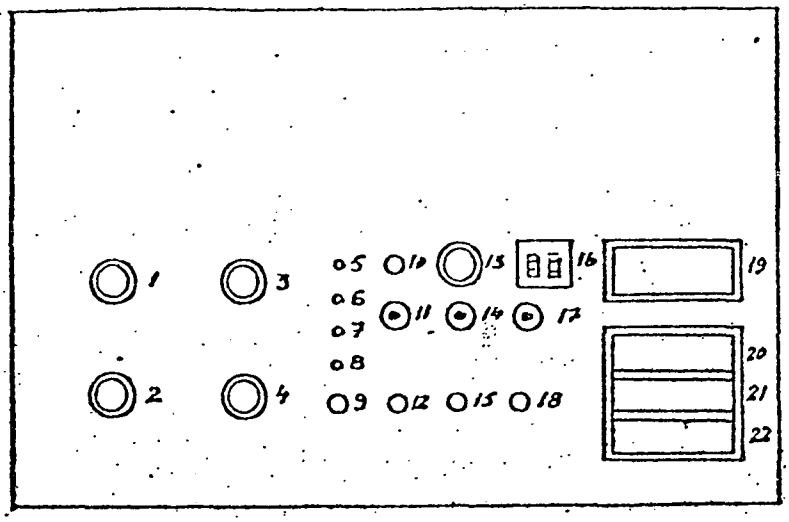


Figure 1

Central unit



Knobs

1. Atmospheric pressure for exhaust volume measuring device
2. Offset, exhaust volume measuring device
3. Ramp speed decceleration
4. Ramp speed acceleration
11. Maximum permitted engine speed
13. No. of cylinders
14. Lower rpm-limit of the test
16. Reference time - torque calibration
17. Upper rpm-limit of the test

Push Knobs

9. Start
10. Reset
12. Reset of torque calibration
15. Manual start of torque calibration
18. Start of testprogram without evacuating the sampled exhaust

Displays

19. Idle speed [rpm]
20. Integrated no. of revolutions [-]

21. Test time [s]
22. Exhaust volume [-]

Indicator lights

5. Reset
6. Start engine
7. Rest ready
8. Weak engine

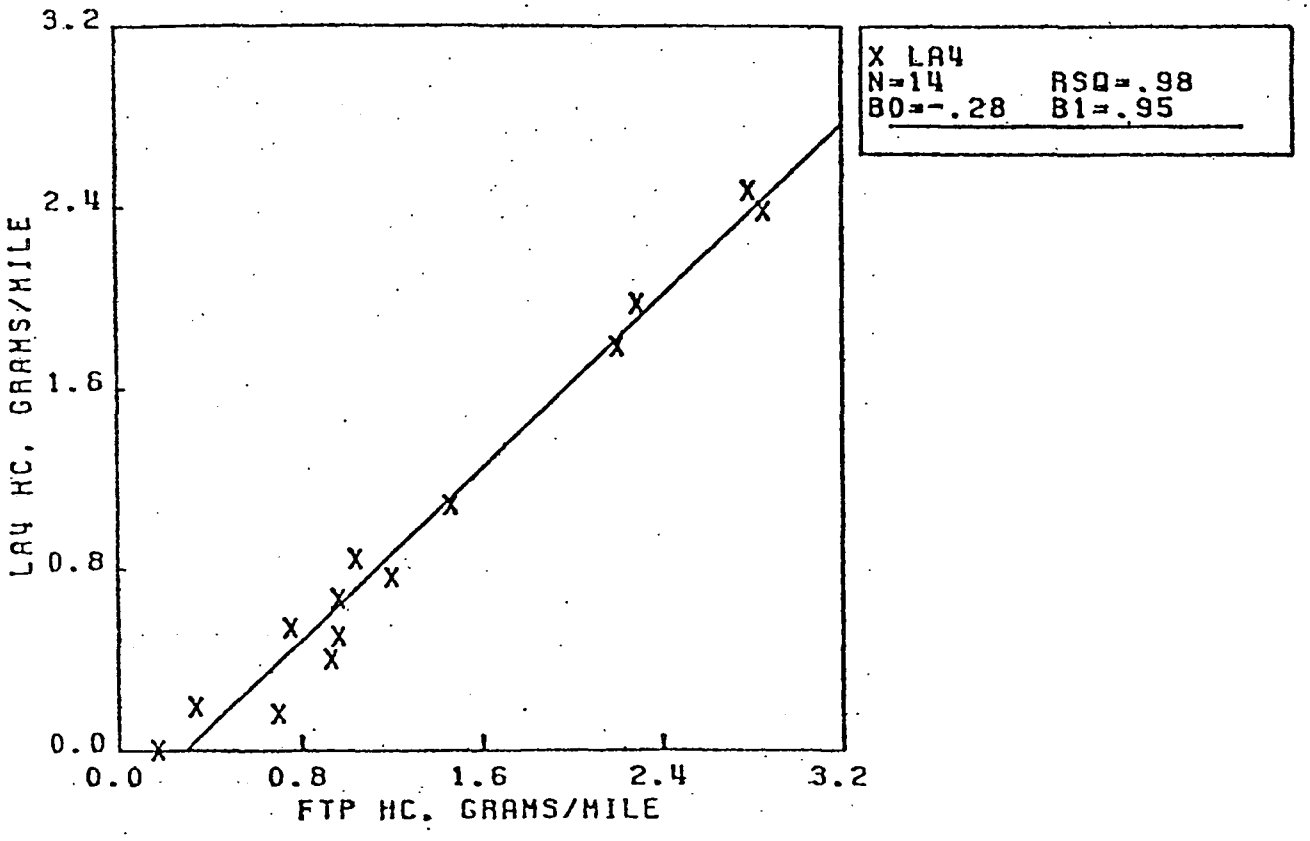
Figure 2

Linear Regression
Coefficient of Determination R^2

Table 1

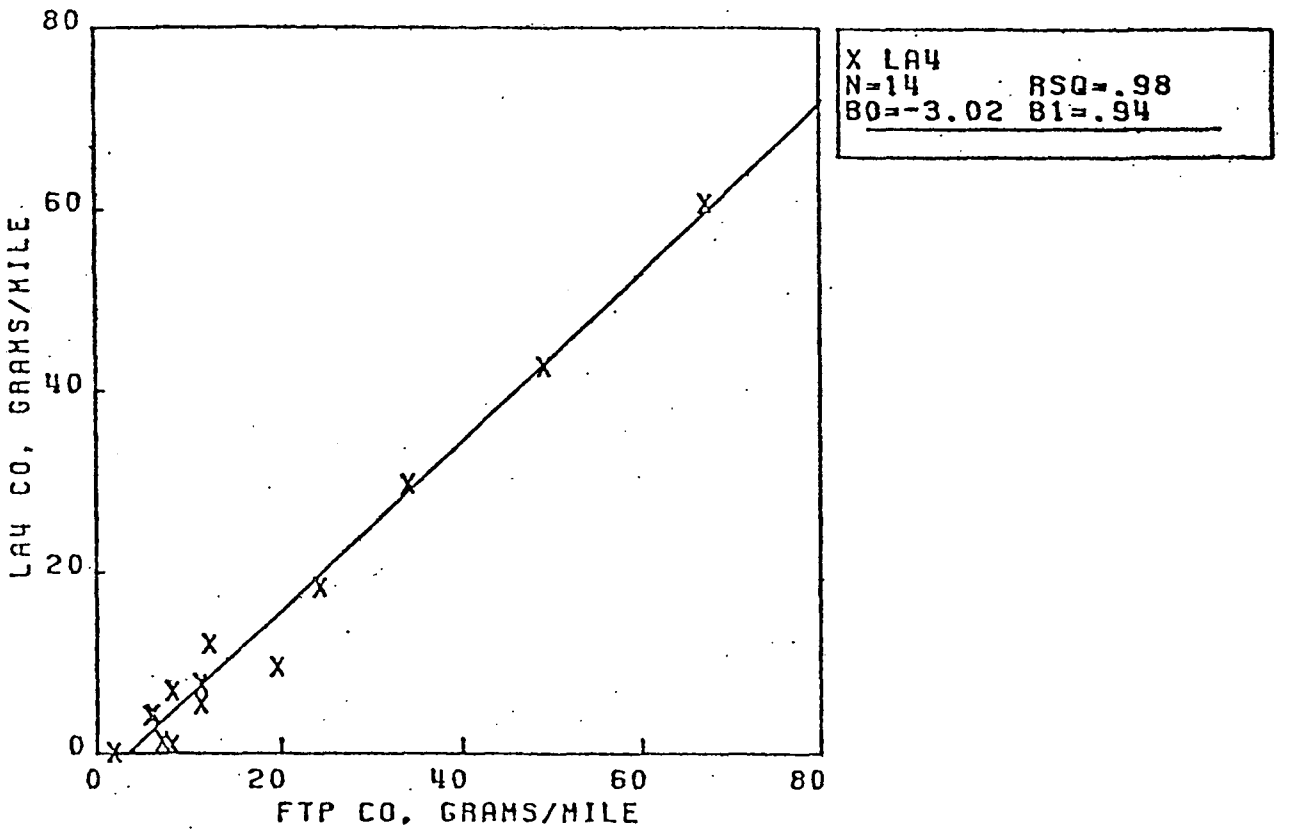
Tests Compared	Sample Size N	HC	CO	NOx
FTP vs LA-4	14	.98	.98	.98
INCOLL 1	14	76	.92	.63
INCOLL 2	13	.63	.82	.72
4 Mode Idle 1				
Idle 1	16	.69	.44	
2500	16	.54	.66	
Idle 2	16	.25	.41	
Drive	13	.61	.46	
4 Mode Idle 2				
Idle 1	15	.41	.42	
2500	15	.71	.61	
Idle 2	15	.43	.42	
Drive	12	.32	.47	
50-Cruise 1	16	.30	.52	
50-Cruise 2	15	.10	.55	
Two-Mode Loaded 1				
30-MPH	15	.46	.73	
Idle	16	.65	.44	
Two-Mode Loaded 2				
30-MPH	15	.36	.53	
Idle	15	.46	.39	

Note: Each short test was performed twice during a test sequence. a 1 identifies the short test following the FTP and a 2 identifies the short test following the LA-4.



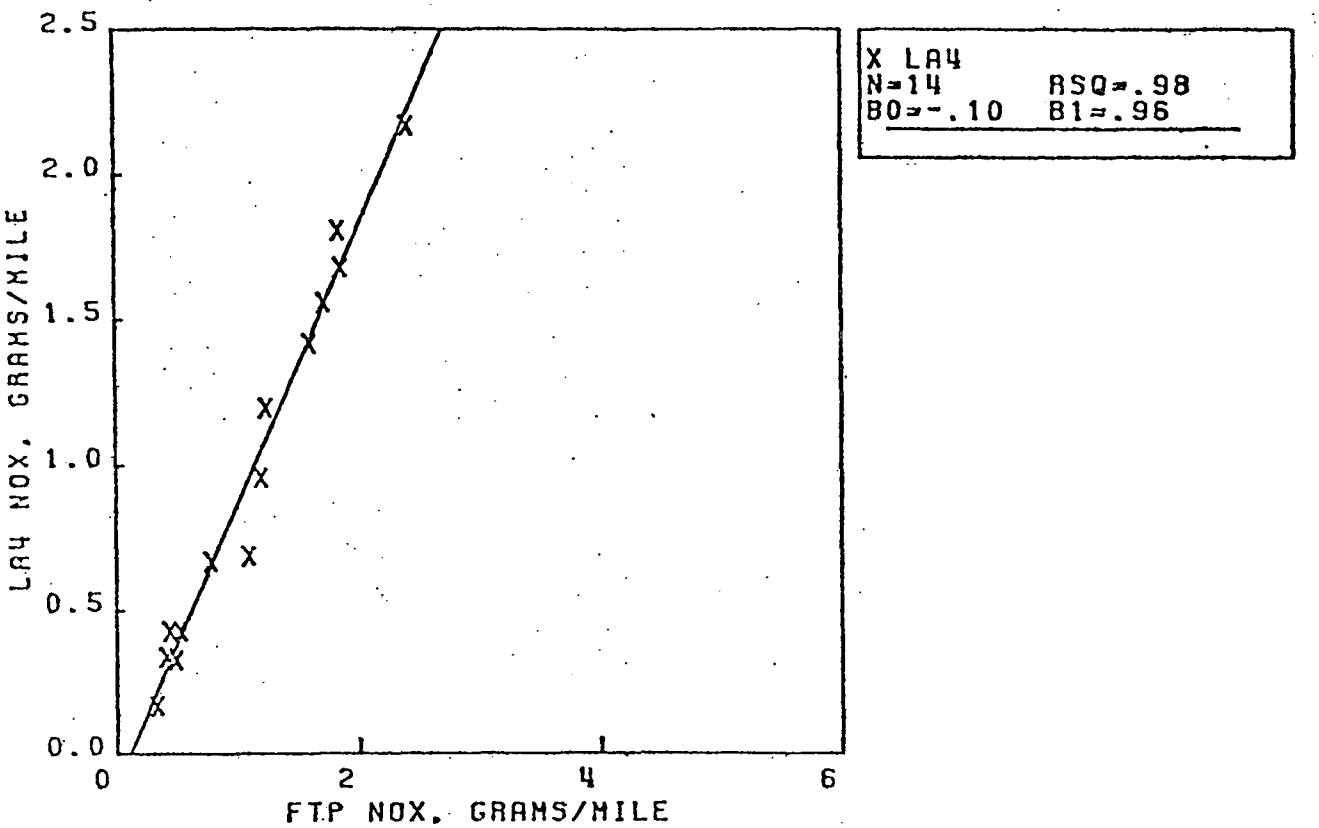
FTP vs. LA 4, HC

Figure 3



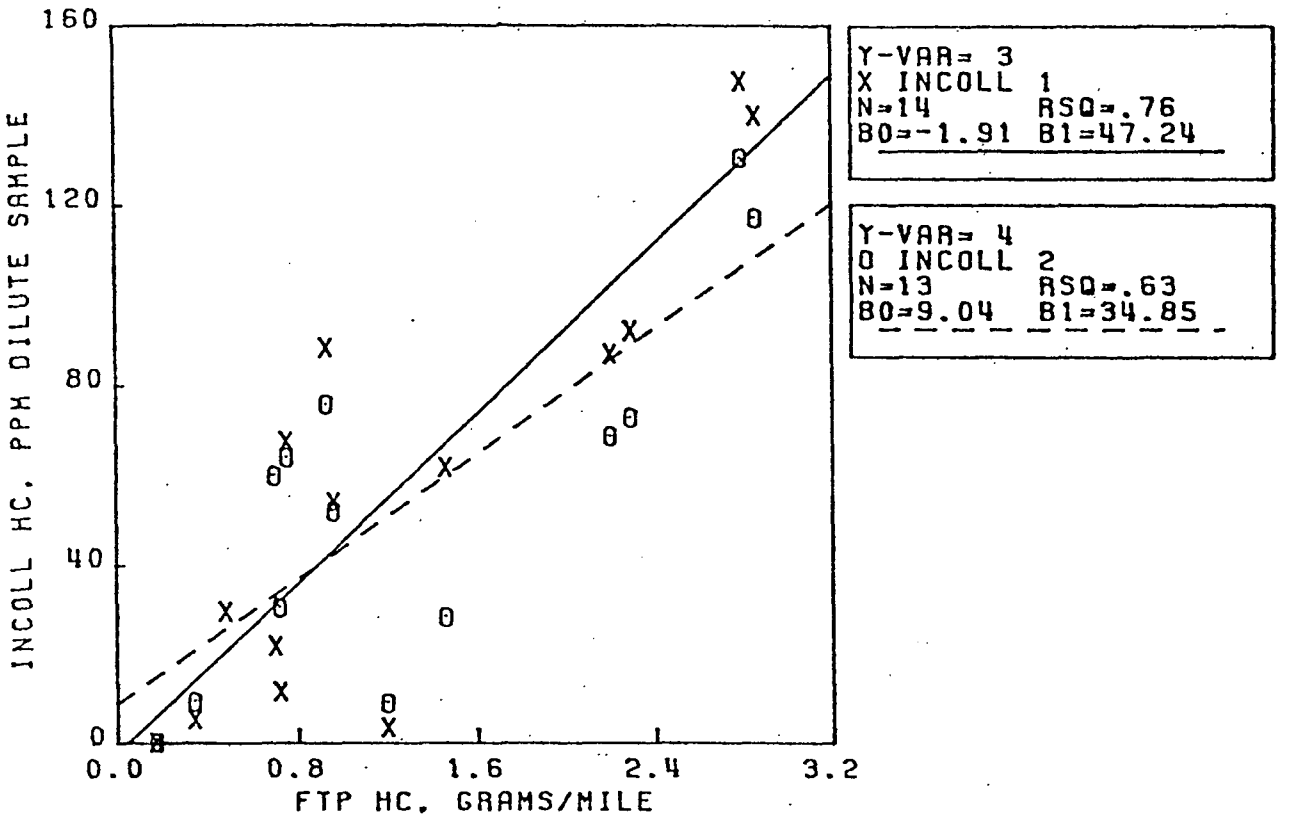
FTP vs. LA 4, CO

Figure 4



FTP vs. LA 4, NOx

Figure 5

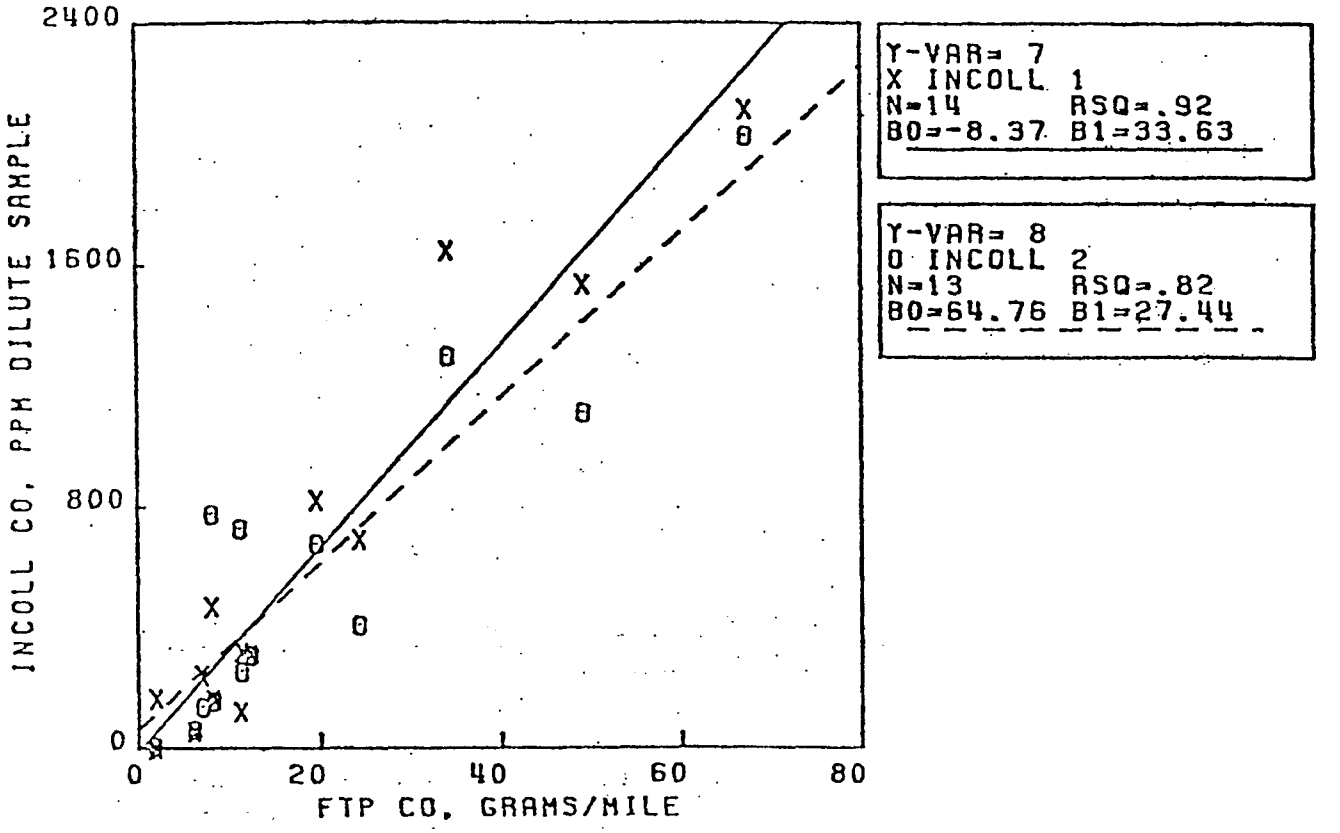


Legend

X INCOLL 1 = 1st INCOLL Test
O INCOLL 2 = 2nd INCOLL Test

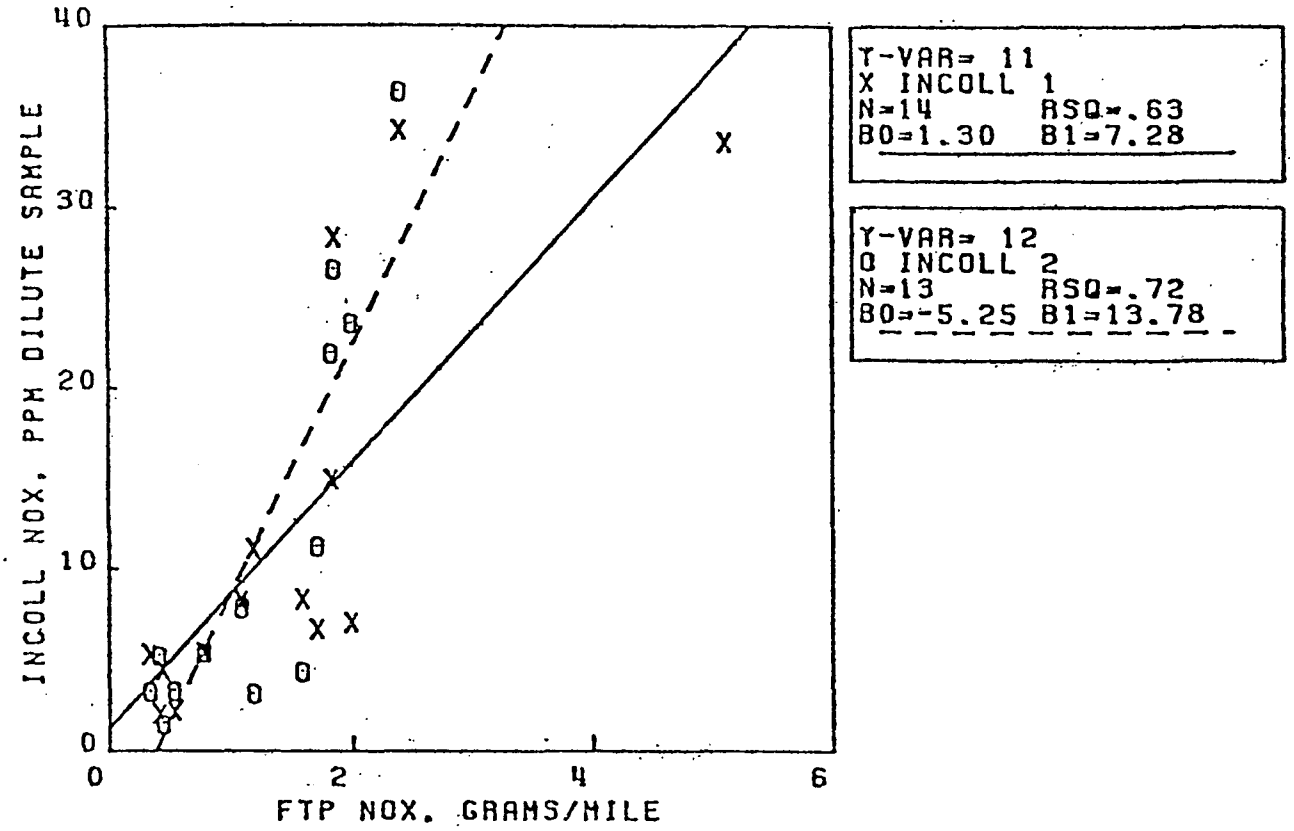
FTP vs. INCOLL, HC

Figure 6



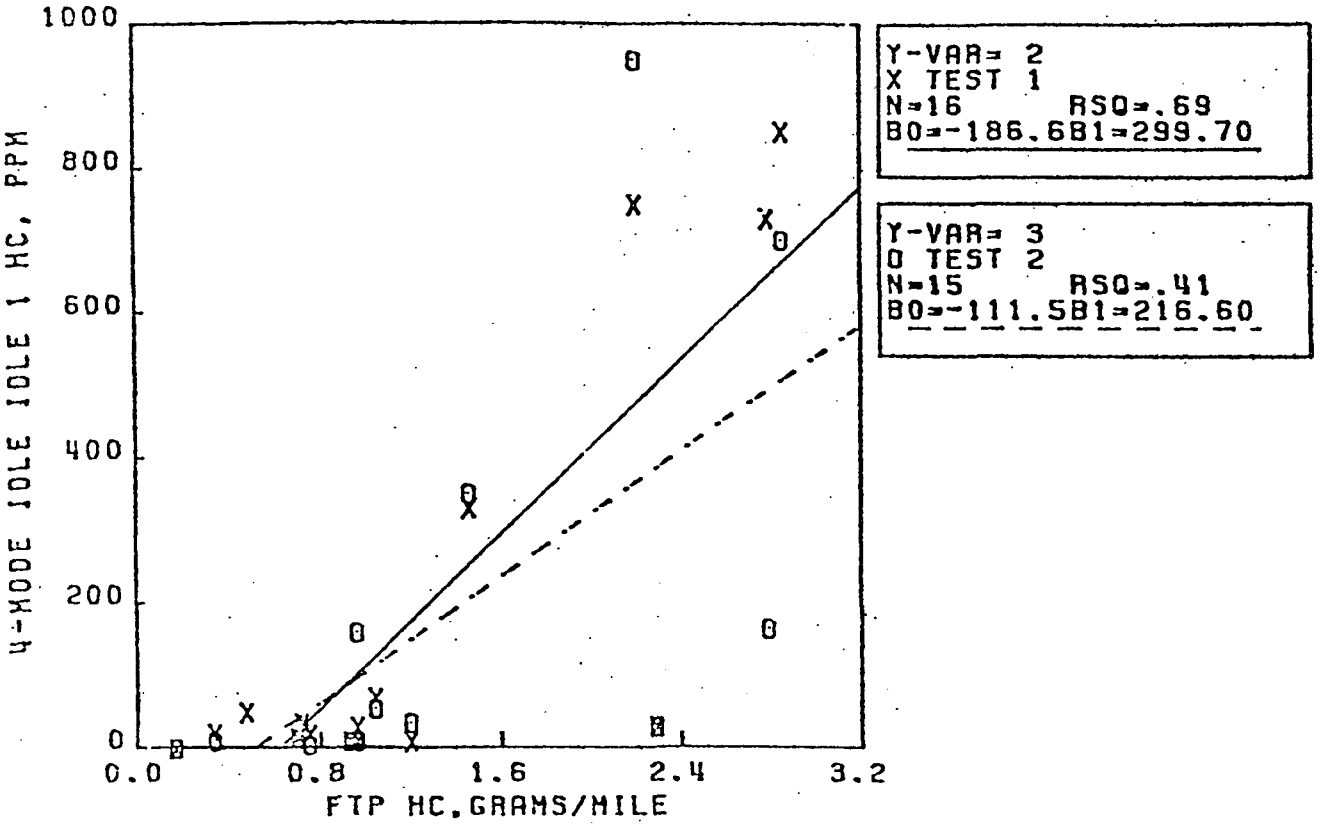
FTP vs. INCOLL, CO

Figure 7



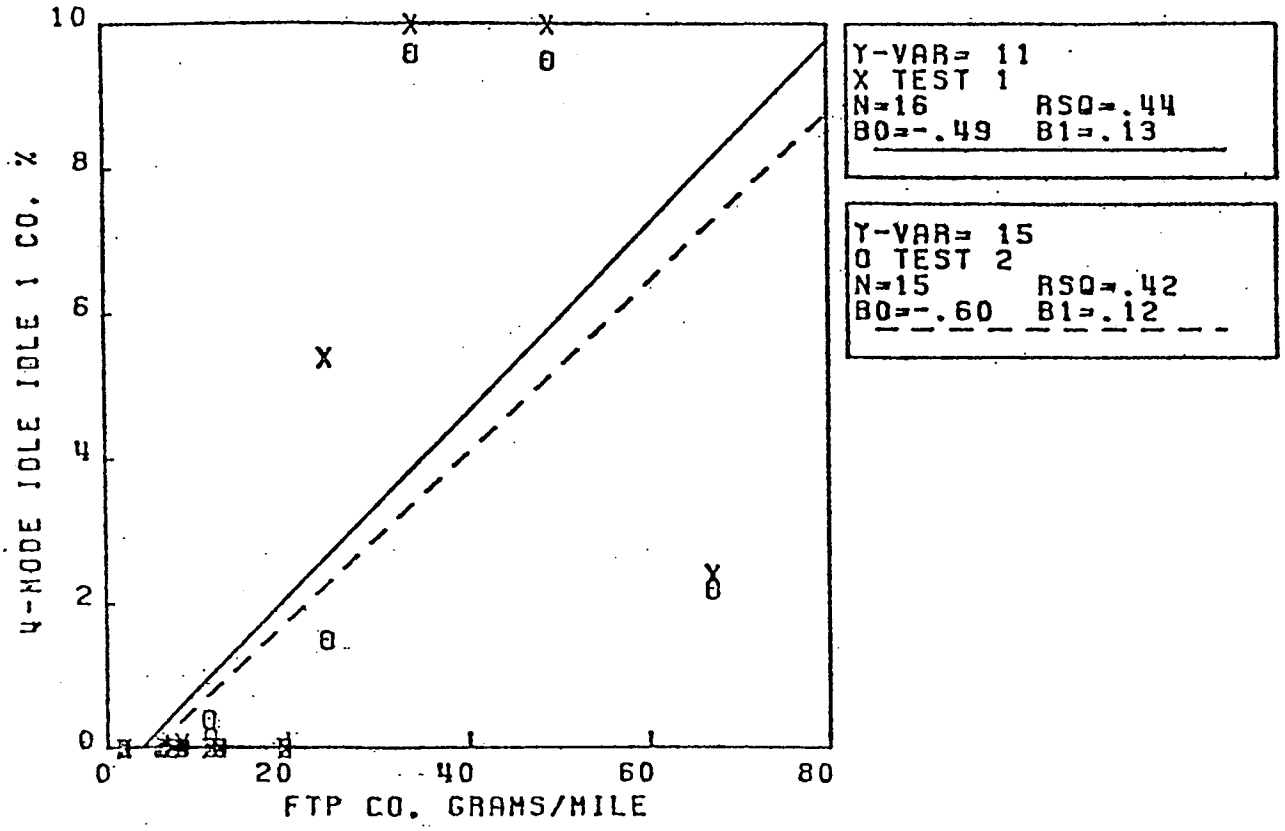
FTP vs. INCOLL, NOx

Figure 8



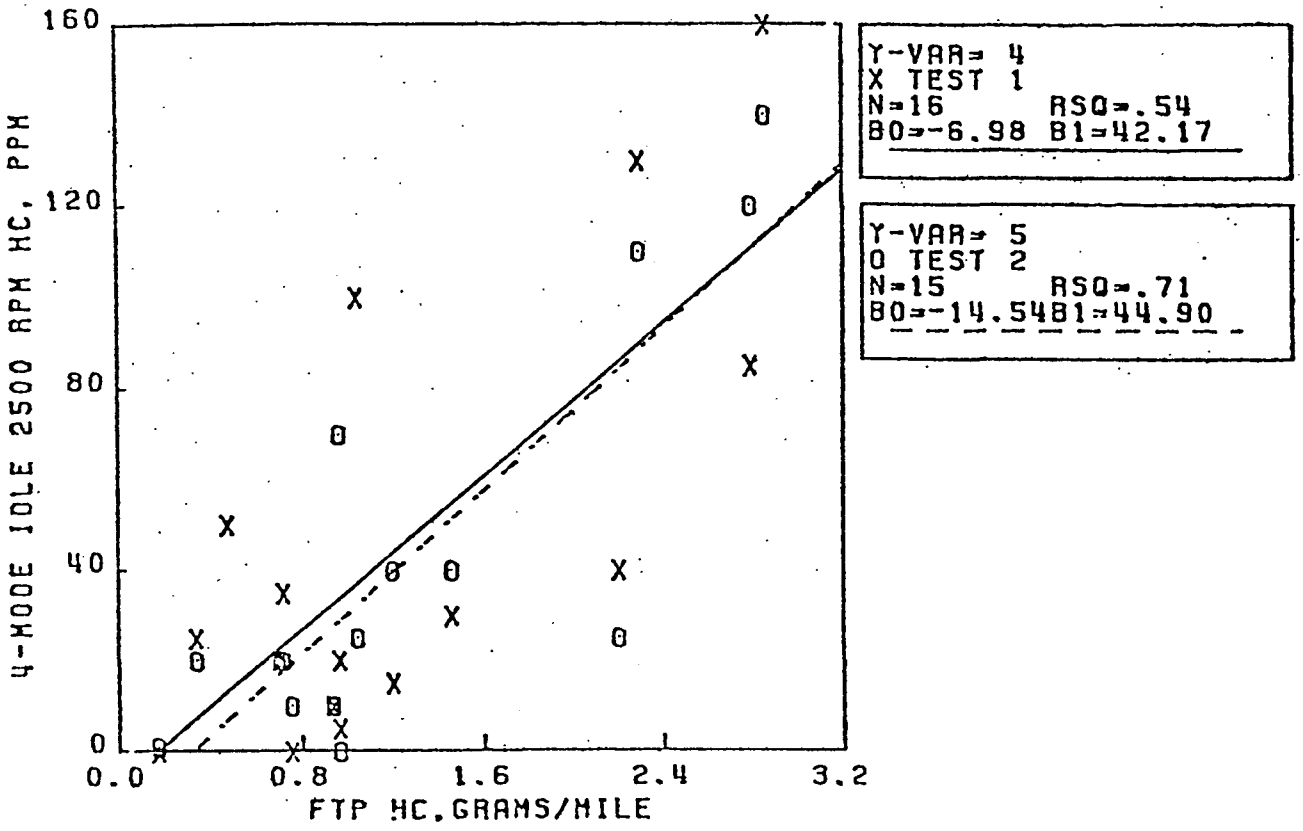
FTP vs. 4-Mode Idle
Idle 1 HC

Figure 9



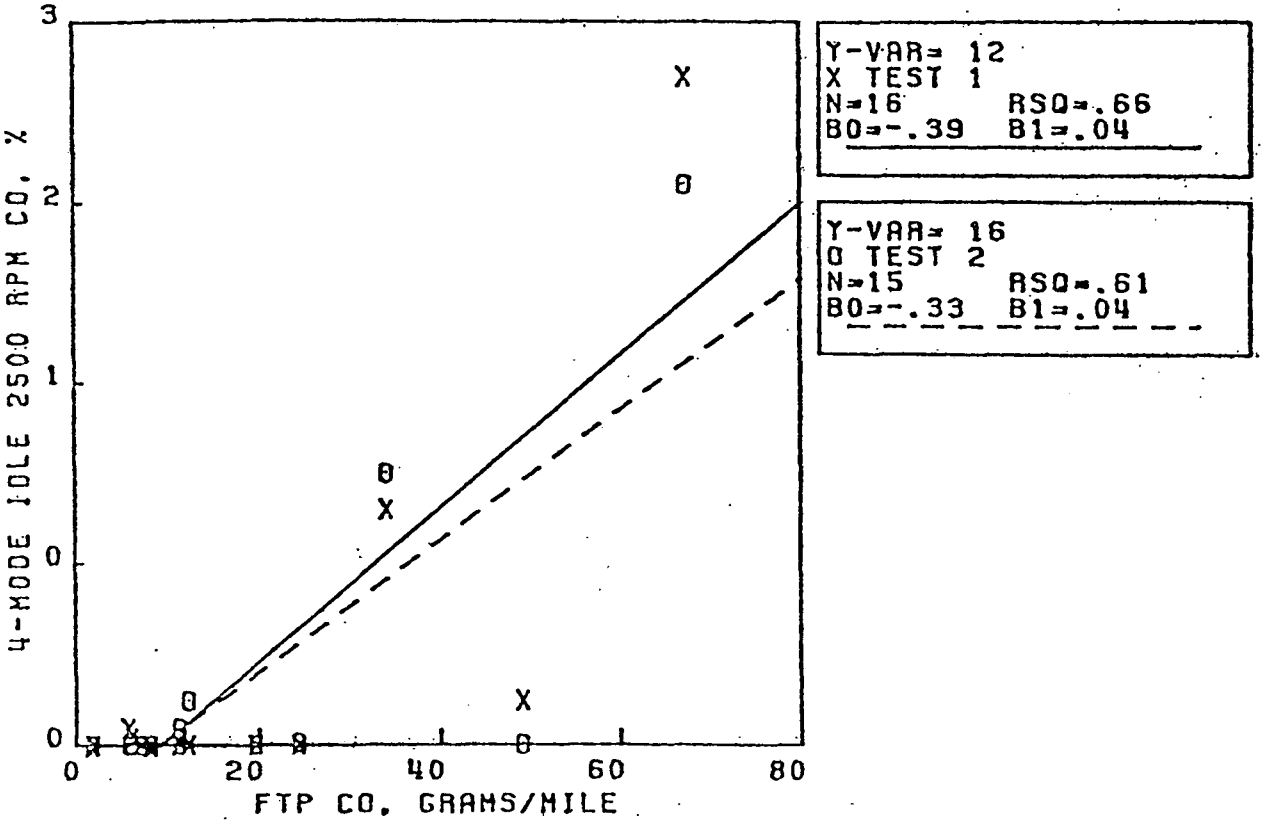
FTP vs. 4-Mode Idle
Idle 1 CO

Figure 10



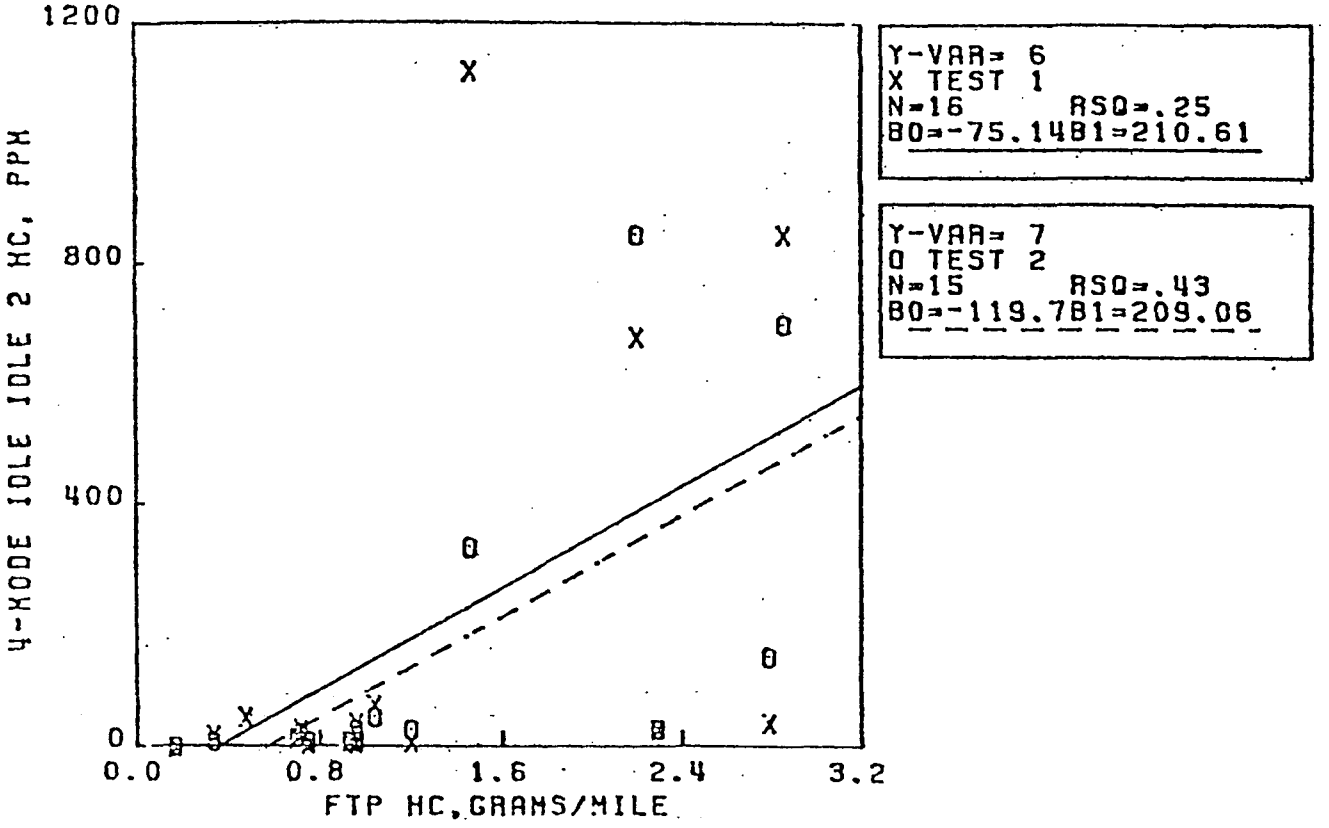
FTP vs. 4-Mode Idle

Figure 11



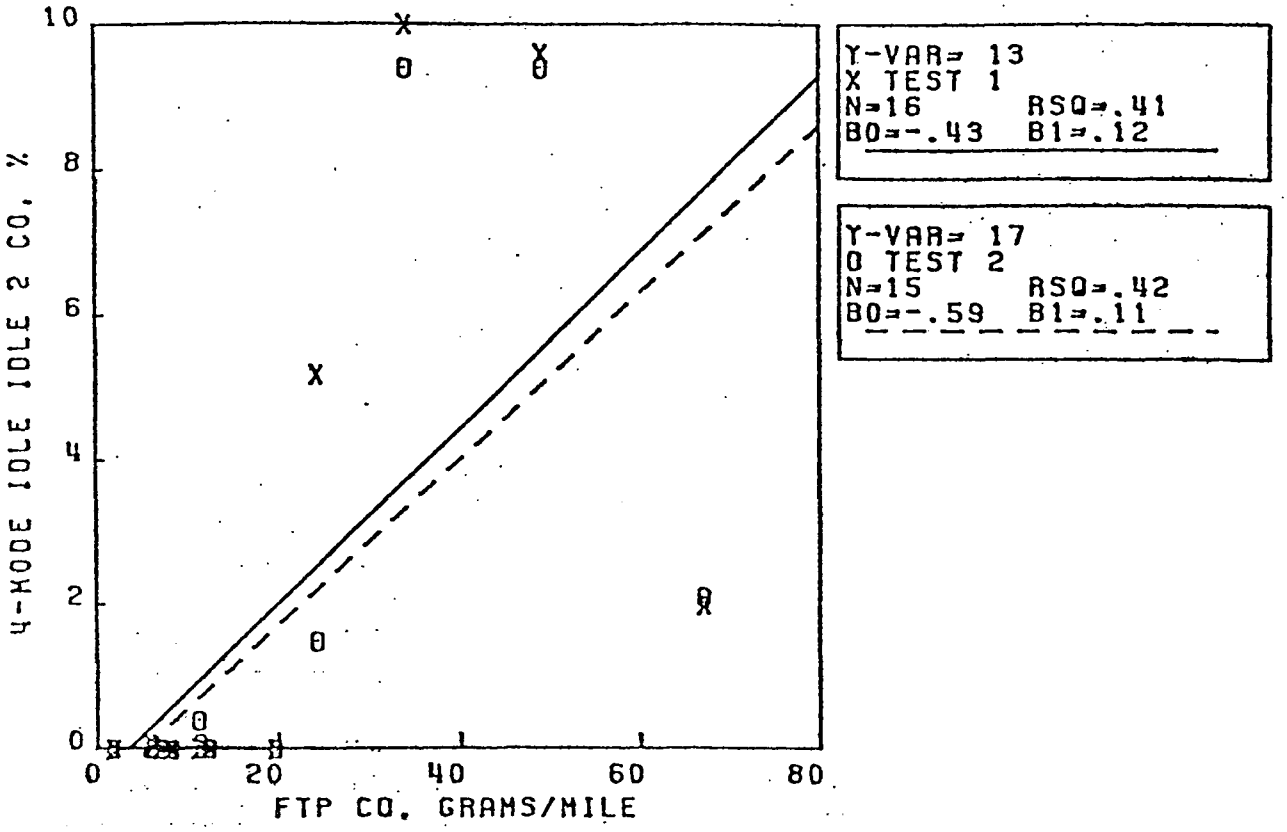
FTP vs. 4-Mode Idle
2500 RPM CO

Figure 12



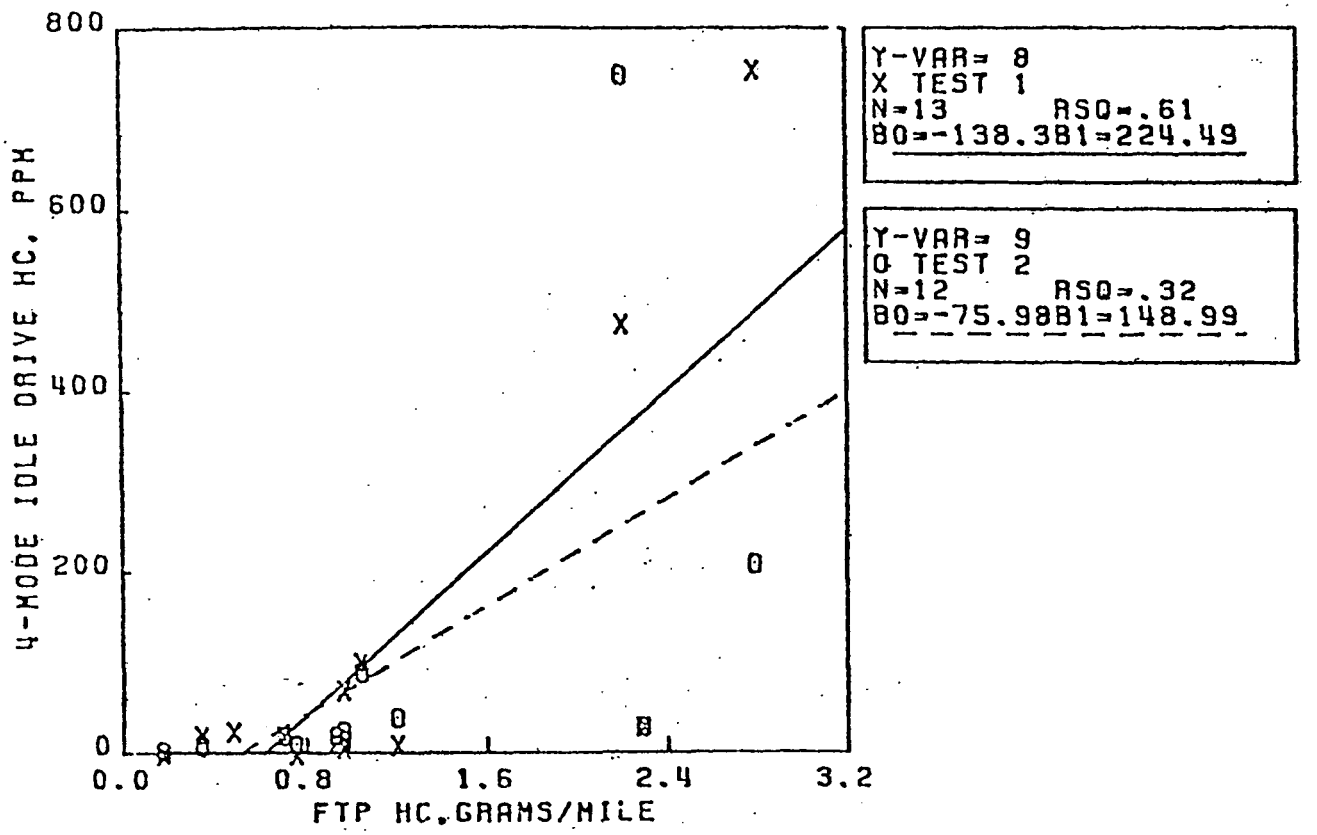
FTP vs. 4-Mode Idle
Idle 2 HC

Figure 13



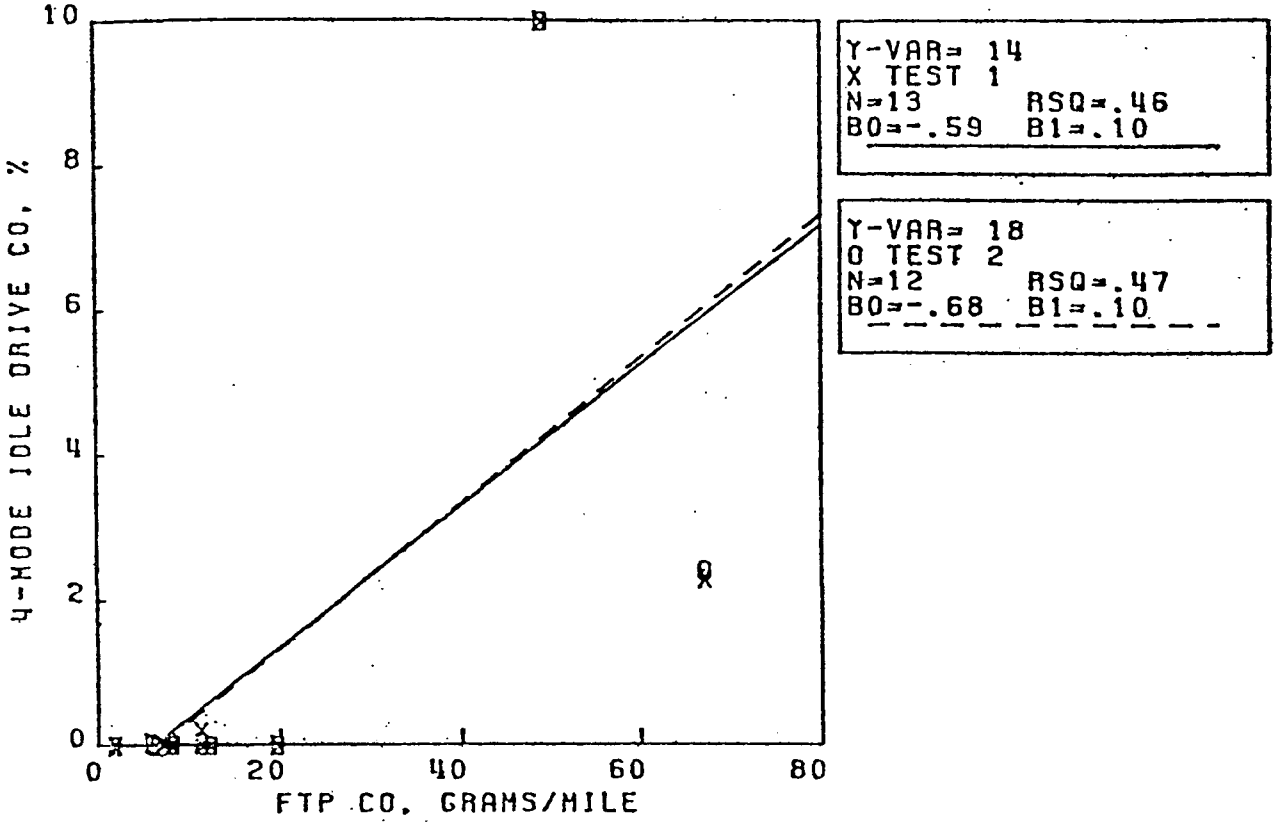
FTP vs. 4-Mode Idle
Idle 2 CO

Figure 14



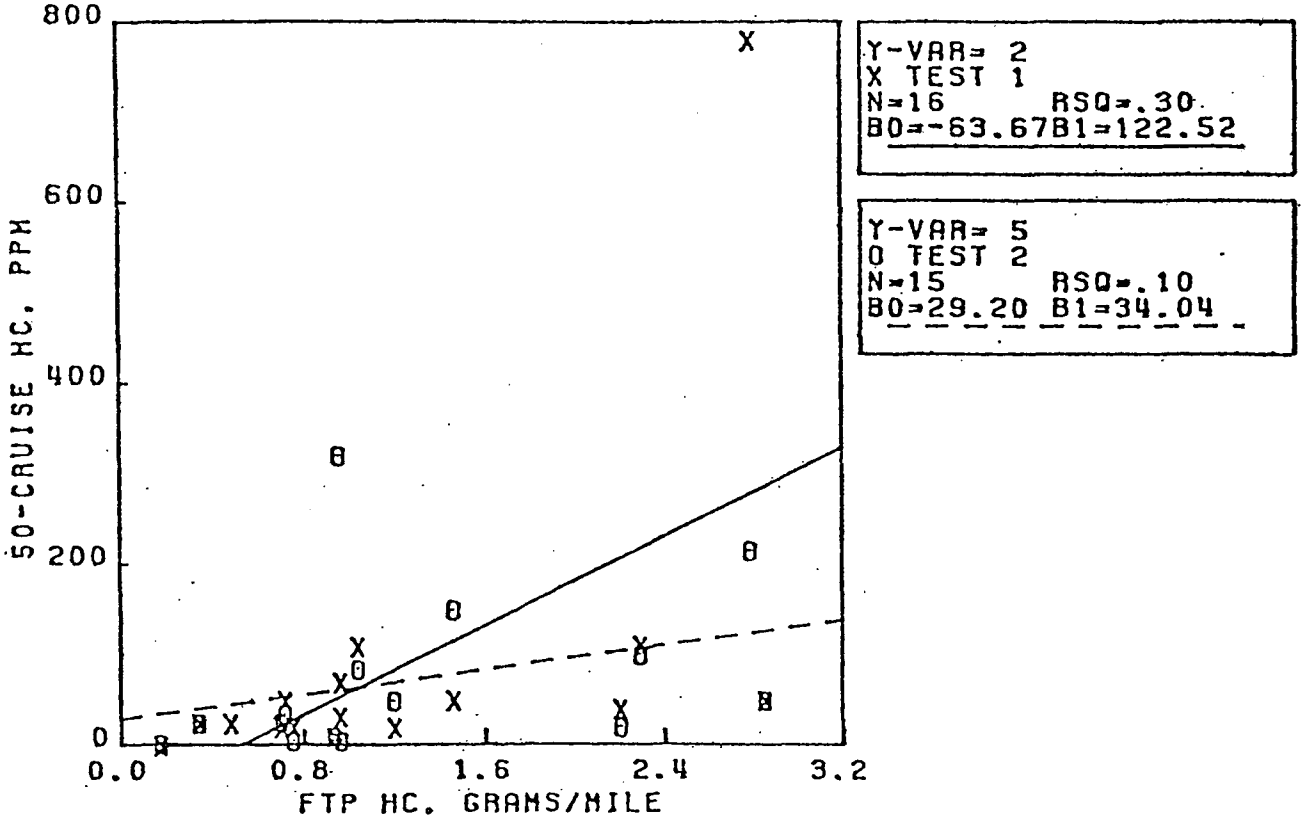
FTP vs. 4-Mode Idle
Idle Drive HC

Figure I5



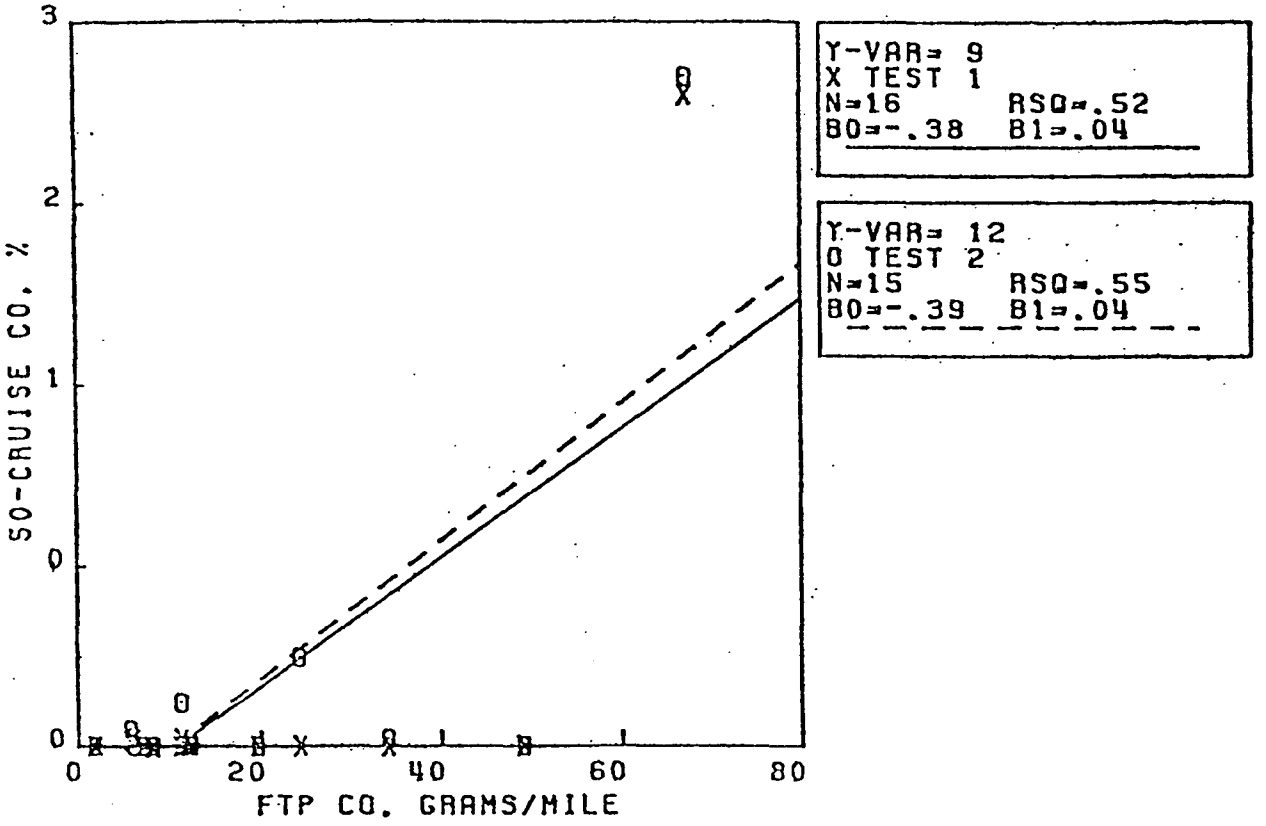
FTP vs. 4-Mode Idle
Idle Drive CO

Figure 16



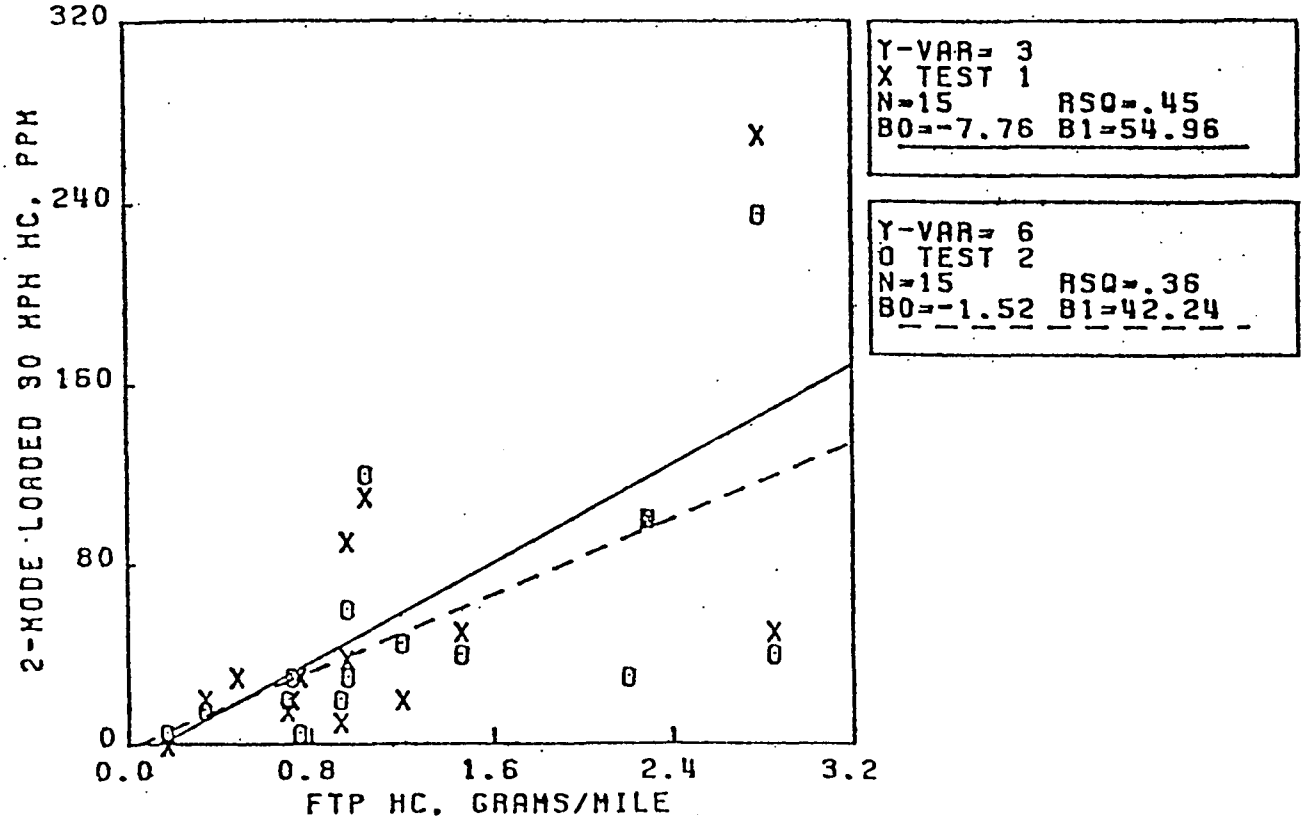
FTP vs. 50-Cruise, HC

Figure 17



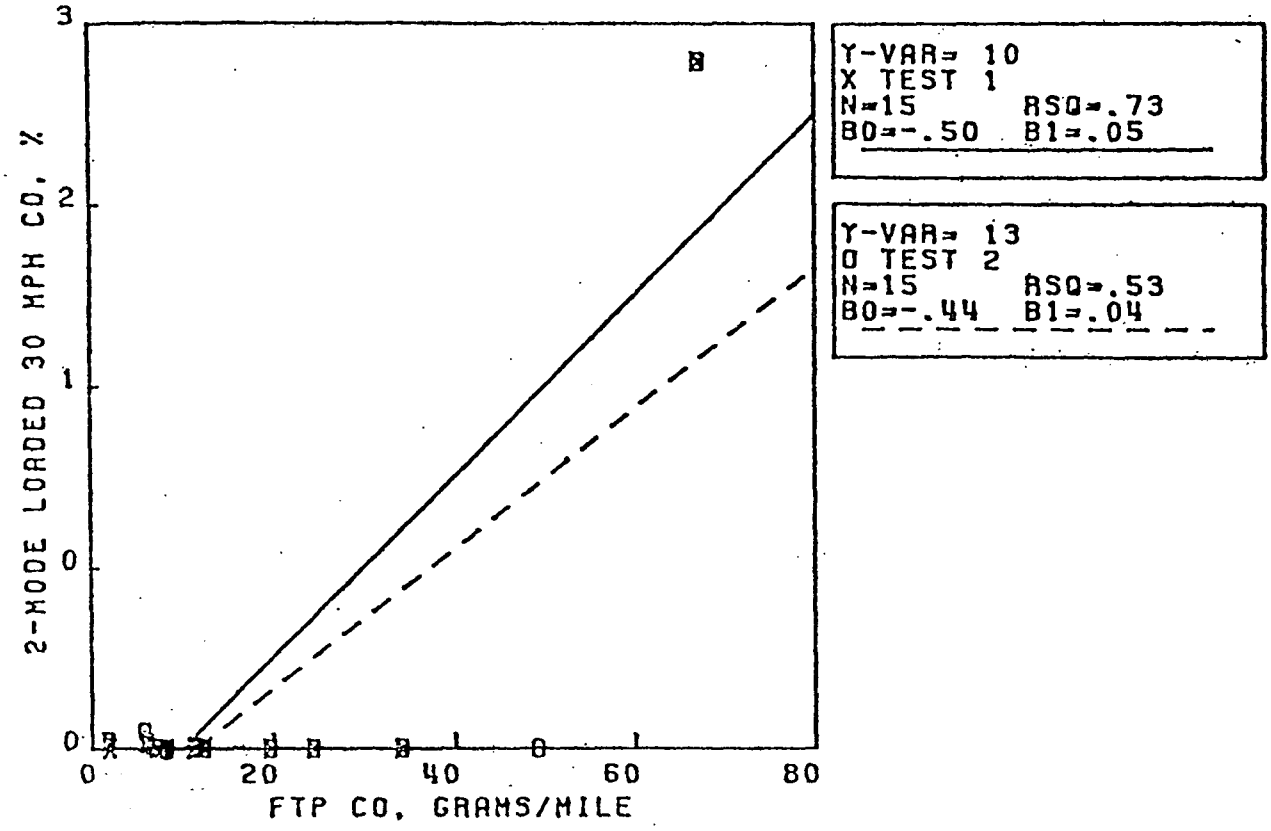
FTP vs. 50-Cruise CO

Figure 18



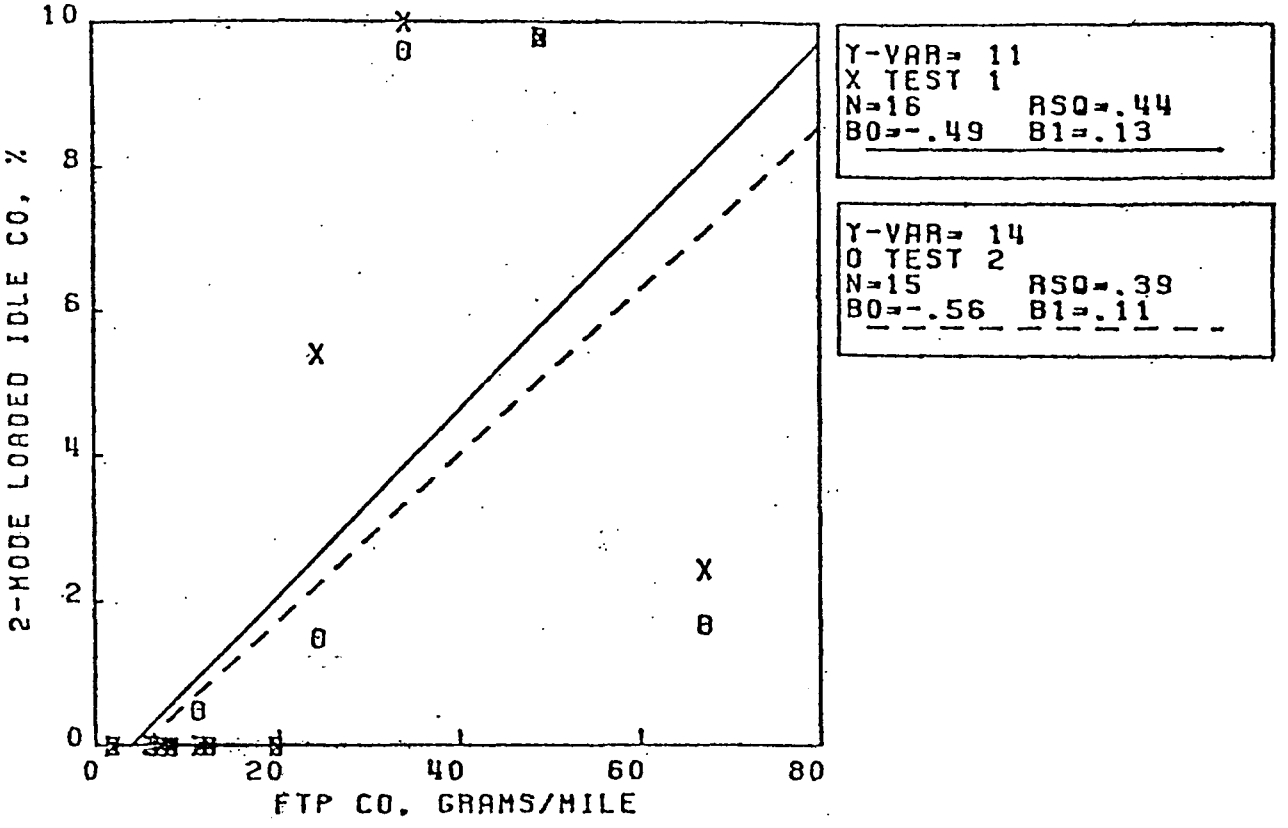
FTP vs. 2-Mode Loaded
30 MPH HC

Figure 19



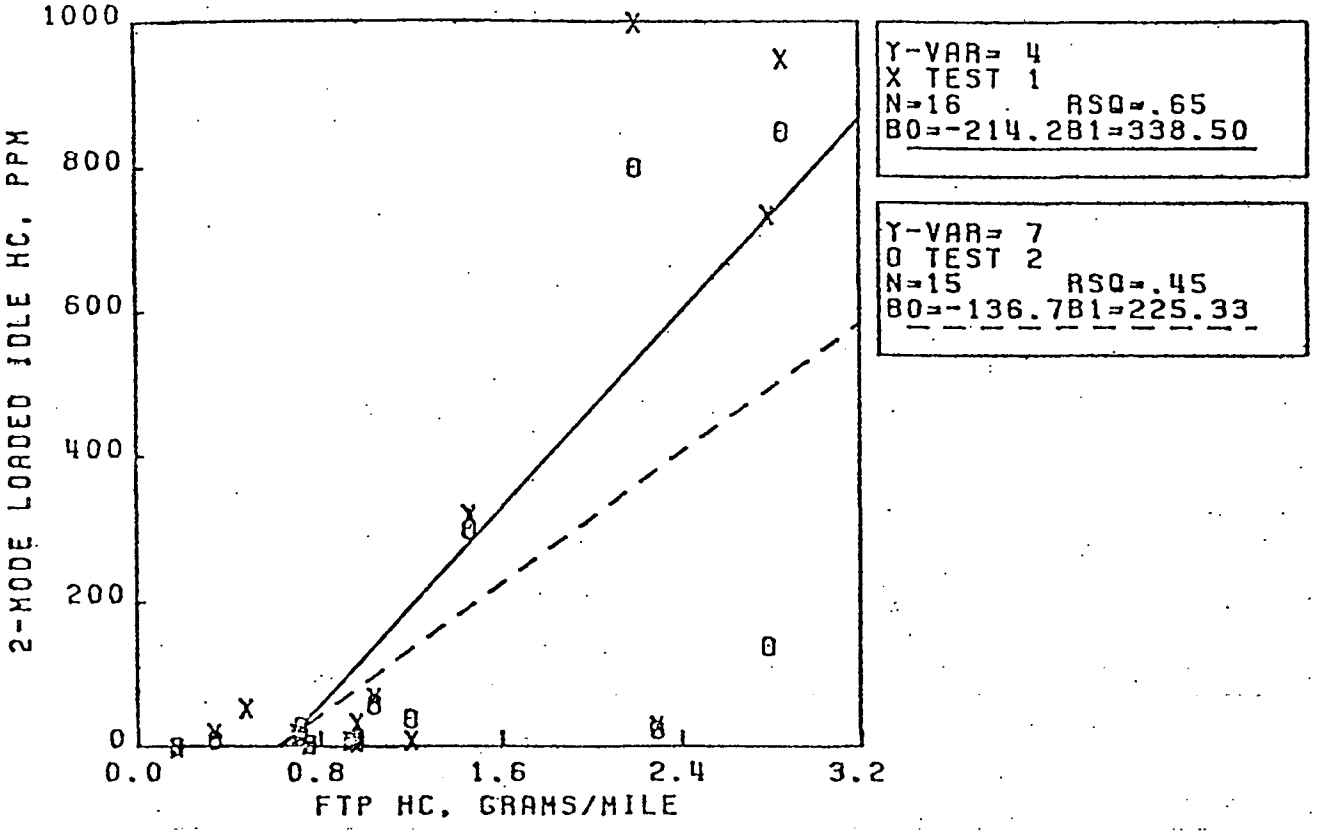
FTP vs. 2-Mode Loaded
30 MPH CO

Figure 20



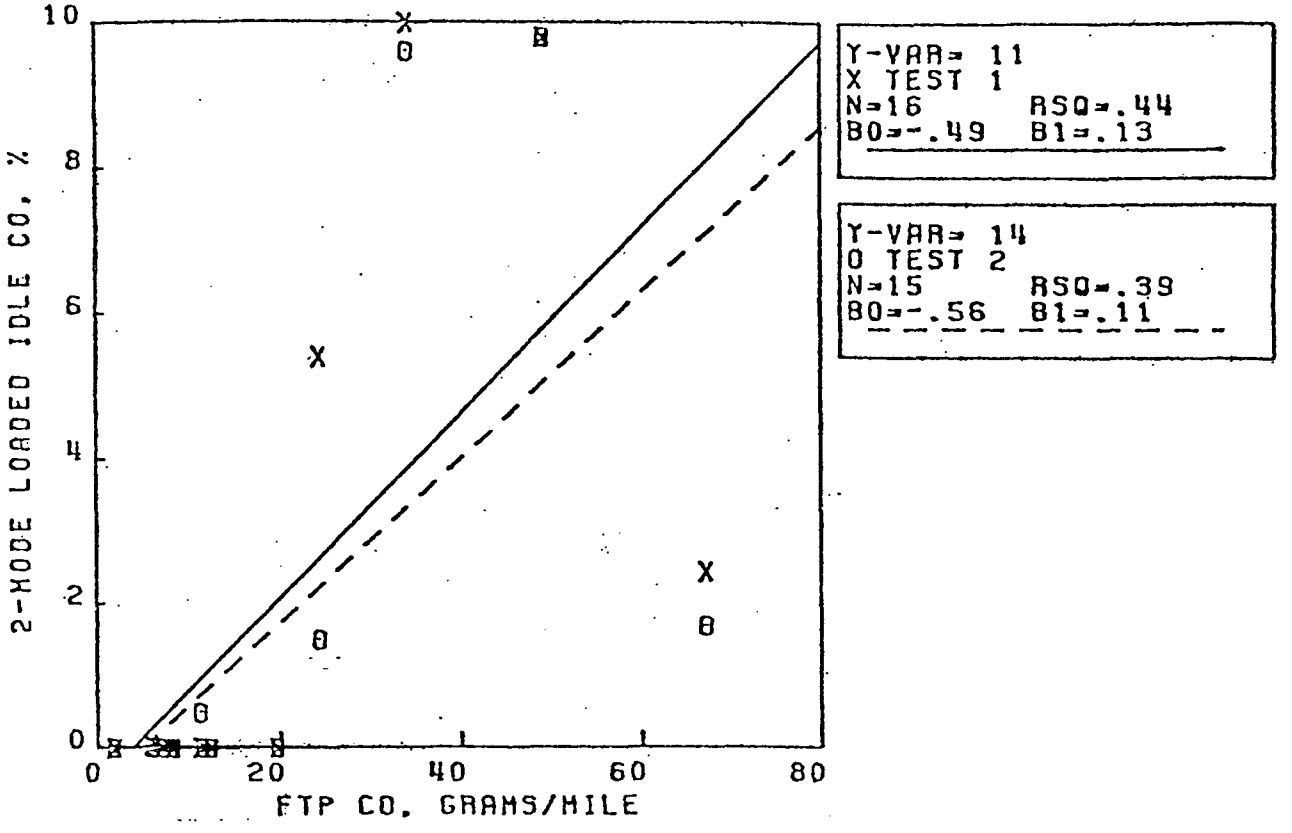
FTP vs. 2-Mode Loaded
Idle Co

Figure 22



FTP vs. 2- Mode Loaded
Idle HC

Figure 21



FTP vs. 2-Mode Loaded
Idle Co

Figure 22

Spearman's RHO
Correlation Coefficients

Table 2

FTP vs	Sample Size N	HC	CO	NOx
LA-4	14	.97	.94	.98
INCOLL 1	14	79	.87	.86
INCOLL 2	13	.68	.82	.81
4 Mode Idle 1				
Idle 1	16	.62	.61	
2500	16	.59	.50	
Idle 2	16	.57	.61	
Drive	13	.63	.50	
4 Mode Idle 2				
Idle 1	15	.80	.68	
2500	15	.77	.64	
Idle 2	15	.83	.68	
Drive	12	.89	.53	
50-Cruise 1	16	.66	.08	
50-Cruise 2	15	.74	-.19	
Two-Mode Loaded 1				
30-MPH	15	.66	.62	
Idle	16	.57	.41	
Two-Mode Loaded 2				
30-MPH	15	.77	-.20	
Idle	15	.80	.62	

Contingency Table Analysis

Table 3

FTP vs.	Sample Size N	Correct Pass (%)	Correct Fail (%)	Ec (%)	Eo (%)	Short Test* Effectiveness
LA4	14	14	86	0	0	1.0
INCOLL Method 1	27	15	48	7	30	.38
INCOLL Method 2	27	11	74	11	4	.95
Each Mode Considered Separately						
4-Mode Idle						
Idle 1	31	19	26	0	55	.32
2500 RPM	31	19	13	0	68	.16
Idle 2	31	19	26	0	55	.32
Drive	25	16	16	0	68	.19
Two-Mode Loaded						
30 MPH	30	30	7	0	73	.08
Idle	31	19	26	0	55	.32
50 Cruise	31	19	10	0	71	.12

$$* \text{ S.T.E.} = \frac{(\text{\# Correctly Failed})}{(\text{\# Correctly Failed}) + (\text{\# Errors of Ommission})}$$

Table 4
Test Vehicles - Certification Standards g/mile

Vehicle	Certification Standard HC	CO	NOx
1975 Dodge Dart	0.9	9.0	2.0
1979 Chevy Nova	1.5	15.0	2.0
1977 Chevy Chevette	1.5	15.0	2.0
1980 Ford Mustang	0.41	7.0	2.0
1980 Chevy Citation	0.41	9.0	1.0
1980 Toyota Celica	0.41	7.0	1.0

Percent Excess Emissions
Identified

Table 5

	N	Short Test Failure Rate	HC	CO	NOx*
LA-4	14	.86	100	100	100
INCOLL Method 1	27	.56	82.4	90.4	91.1
INCOLL Method 2	27	.85	100	96.9	100
4 Mode Idle					
Idle 1	31	.26	56.3	84.3	
2500	31	.13	38.0	50.6	
Idle 2	31	.26	56.3	84.3	
Drive	25	.16	49.3	80.8	
Two-Mode Loaded					
30 MPH	30	.07	26.7	44.2	
Idle	31	.26	56.3	84.3	
50 Cruise	31	.10	27	38.9	

* NOx correlations were done only for the LA-4 and INCOLL tests.

Descriptions of Abbreviations and
Units for Data Set Variables

S 50C H 1

- 1 — Test Phase
- H — Pollutant Measured
- S 50C — Short Test - 50 Cruise

S30 L H 1

- 1 — Test Phase
- H — Pollutant Measured
- L — L = Loaded Mode, I = Idle Mode
- S30 — Short Test - Two Mode Loaded

S4MI 1 H 1

- 1 — Test Phase
- H — Pollutant Measured
- 1 — 1 = Idle, 2 = 2500, 3 = Idle, 4 = Idle in Drive
- S4MI — Short Test - Four Mode Idle

Test Phase 1 = After FTP 2 = After LA-4

Pollutant measured H = HC as ppm hexane
C = % CO

FTP LA4 H

- H — Pollutant measured in grams/mile
  H = HC C = CO N = NOx 2 = CO_2
- FTP LA4 — Test Procedure

F 1 H

- H — Pollutant measured as concentrations
  H = ppm HC C ppm CO N = ppm NOx
  2 = percent CO_2
- 1 — Bag sample or I = INCOLL Sample
- F — Test Procedure

F = FTP L = LA-4 or phase of test if bag sample = I

ATTACHMENT 1

Case Description

Case	Vehicle	Configuration
1	Dart	Stock
2	Dart	10% Misfire
3	Dart	Rich Idle
4	Chevette	Stock
5	Chevette	Rich Idle
6	Chevette	Vacuum Leak
7	Mustang	Stock
8	Mustang	10% Misfire
9	Mustang	Rich Idle
10	Nova	Stock
11	Toyota	Stock
12	Toyota	Closed Loop Disabled
13	Citation	Stock Poisoned
14	Citation	EGO Disabled Poisoned
15	Citation	EGO Disabled Poisoned
16	Citation	Stock Poisoned

ATTACHMENT 1 (continued)

0.	17.	51.	21.	54.
CASE#	FTPH	LA4H	FIH	LIH
0.	32.	63.	36.	66.
CASE#	FTPC	LA4C	FIC	LIC
0.	22.	55.	26.	58.
CASE#	FTPH	LA4H	FIH	LIH
1	.70000	.17000	22.300	60.200
1	8.1100	1.0900	473.00	777.00
1	1.8300	1.8100	14.960	21.960
2	2.2900	1.9800	92.400	73.100
2	7.0100	1.5600	244.00	141.00
2	2.4000	2.1700	34.300	36.400
3	.93000	.41000	88.800	76.200
3	19.600	9.7500	824.00	679.00
3	1.8500	1.6800	28.400	26.600
4	1.4600	1.0900	62.200	28.700
4	24.300	18.500	694.00	412.00
4	1.5900	1.4200	8.4000	4.4100
5	.72000		12.100	30.900
5	11.200		125.00	729.00
5	1.9900		7.1300	23.630
6	2.8500	2.3900	140.28	117.38
6	34.100	29.800	1650.0	1300.0
6	1.7100	1.5600	6.7600	11.250
7	.34000	.20000	5.7000	9.6900
7	11.350	7.9600	324.00	257.00
7	.78000	.67000	5.4700	5.4500
8	1.2000	.77000	3.9600	9.3500
8	12.340	12.290	315.00	312.00
8	1.0900	.69000	8.2900	7.8900
9	2.2000	1.7900	87.270	68.960
9	49.100	42.800	1538.0	1114.0
9	.41000	.34000	2.1100	5.2500
10	.48000		30.070	
10	1.8900		168.35	
10	5.1000		33.680	
11	.17000	.10000 -1	.67000	.54000
11	1.7500	.28000	2.9000	8.4800
11	.33000	.17000	5.3800	3.3100
12	2.7850	2.4810	147.91	130.78
12	67.060	60.830	2117.0	2028.2
12	.44000	.43000	4.5000	1.5200
13	1.0400	.85000		
13	5.7800	4.3700		
13	.49000	.33000		
14	.96000	.51000		
14	11.350	5.6500		
14	1.2300	1.2000		
15	.75300	.54900	67.970	64.220
15	8.2100	7.0700	164.81	159.50
15	1.1700	.96000	11.140	3.2100
16	.96100	.67400	54.390	52.370
16	6.1100	4.5900	59.940	65.120
16	.53000	.43000	2.2600	3.3600

Numerical Results
FTP, LA 4 and INCOLL

ATTACHMENT 2

0.	17.	51.	5.	7.	9.	11.	39.	41.	43.	45.
CASE#	FTPH	LA4H	S4HI1H1	S4HI2H1	S4HI3H1	S4HI4H1	S4HI1H2	S4HI2H2	S4HI3H2	S4HI4H2
0.	32.	63.	6.	8.	10.	12.	40.	42.	44.	46.
CASE#	FTPC	LA4C	S4HI1C1	S4HI2C1	S4HI3C1	S4HI4C1	S4HI1C2	S4HI2C2	S4HI3C2	S4HI4C2
0.	22.	55.								
CASE#	FTPH	LA4H								
1	.70000	.17000	15.000	20.000	15.000	20.000	15.000	20.000	15.000	20.000
1	8.1100	1.0900	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1
1	1.8300	1.8100								
2	2.2900	1.9800	30.000	130.00	30.000	30.000	30.000	110.00	30.000	30.000
2	7.0100	1.5600	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1	0.
2	2.4000	2.1700								
3	.93000	.41000	10.000	10.000	10.000	15.000	10.000	10.000	10.000	20.000
3	19.600	9.7500	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1
3	1.8500	1.6800								
4	1.4600	1.0900	330.00	30.000	1120.0		350.00	40.000	330.00	
4	24.300	18.500	5.4000	.10000 -1	5.2000		1.5000	.20000 -1	1.5000	
4	1.5900	1.4200								
5	.72000		35.000	35.000	30.000		25.000	20.000	25.000	
5	11.200		.10000 -1	.10000 -1	.10000 -1		.40000	.10000 -1	.40000	
5	1.9500									
6	2.8500	2.3900	850.00	160.00	850.00		700.00	140.00	700.00	
6	34.100	29.800	10.000	1.3000	10.000		9.6000	1.5000	9.4000	
6	1.7100	1.5600								
7	.34000	.20000	20.000	25.000	20.000	20.000	10.000	20.000	10.000	10.000
7	11.350	7.9600	.10000 -1	.50000 -1	.10000 -1	.20000	.10000 -1	.10000	.10000 -1	.10000 -1
7	.78000	.67000								
8	1.2000	.77000	10.000	15.000	10.000	10.000	35.000	40.000	30.000	40.000
8	12.340	12.290	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.25000	.10000 -1	.10000 -1
8	1.0900	.69000								
9	2.2000	1.7900	750.00	40.000	680.00	475.00	950.00	25.000	850.00	750.00
9	49.100	42.800	10.000	.25000	9.6000	10.000	9.5000	.10000 -1	9.4000	10.000
9	.41000	.34000								
10	.48000		50.000	50.000	50.000	25.000				
10	1.6900		.10000 -1	.10000 -1	.10000 -1	.10000 -1				
10	5.1000									
11	.17000	.10000 -1	0.	0.	0.	0.	0.	1.0000	1.0000	3.0000
11	1.7500	.28000	0.	0.	0.	0.	.10000 -1	.10000 -1	.10000 -1	.10000 -1
11	.33000	.17000								
12	2.7850	2.4810	730.00	85.000	40.000	755.00	165.00	120.00	150.00	210.00
12	67.060	60.830	2.4000	3.7000	2.0000	2.3000	2.2000	3.1000	2.1000	2.4000
12	.44000	.43000								
13	1.0400	.85000	70.000	100.00	70.000	100.00	55.000	25.000	50.000	90.000
13	5.7800	4.3700	.50000 -1	.10000	.10000	.50000 -1	.10000 -1	.10000 -1	.10000 -1	.50000 -1
13	.49000	.33000								
14	.98000	.51000	10.000	5.0000	6.0000	6.0000	160.00	70.000	30.000	15.000
14	11.350	5.6500	.20000 -1	.20000 -1	.20000 -1	.20000 -1	.15000	.10000	.80000 -1	.70000 -1
14	1.2300	1.2000								
15	.75300	.54900	20.000	0.	5.0000	0.	5.0000	10.000	10.000	10.000
15	8.2100	7.0700	.60000 -1	0.	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.20000 -1
15	1.1900	.96000								
16	.96100	.67400	30.000	20.000	40.000	70.000	10.000	0.	10.000	25.000
16	6.1100	4.5900	.20000 -1	.50000 -1	.60000 -1	.30000 -1	.20000 -1	.10000 -1	.20000 -1	0.
16	.53000	.43000								

Numerical Results
FTP, LA 4 and 4-Mode Idle

ATTACHMENT 3

0.	17.	51.	3.	13.	15.	37.	47.	49.
CASE#	FTPH	LA4H	S50CH1	S30LH1	S30IH1	S50CH2	S30LH2	S30IH2
0.	32.	63.	4.	14.	16.	38.	48.	50.
CASE#	FTPC	LA4C	S50CC1	S30LC1	S30IC1	S50CC2	S30LC2	S30IC2
0.	22.	55.						
CASE#	FTPH	LA4H						
1	.70000	.17000	20.000	15.000	20.000	25.000	20.000	15.000
1	8.1100	1.0900	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1
1	1.8300	1.8100						
2	2.2900	1.9800	110.00	100.00	30.000	100.00	100.00	25.000
2	7.0100	1.5600	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1
2	2.4000	2.1700						
3	.93000	.41000	10.000	10.000	10.000	10.000	20.000	10.000
3	19.600	9.7500	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1
3	1.8500	1.6800						
4	1.4600	1.0900	50.000	50.000	320.00	150.00	40.000	300.00
4	24.300	18.500	.10000 -1	.10000 -1	5.4000	.50000	.10000 -1	1.5000
4	1.5900	1.4200						
5	.72000		50.000	20.000	20.000	35.000	30.000	30.000
5	11.200		.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.50000
5	1.9900							
6	2.8500	2.3900	50.000	50.000	950.00	50.000	40.000	850.00
6	34.100	29.800	.10000 -1	.10000 -1	10.000	.50000 -1	.10000 -1	9.6000
6	1.7100	1.5500						
7	.34000	.20000	25.000	20.000	20.000	25.000	15.000	10.000
7	11.350	7.9600	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1
7	.78000	.67000						
8	1.2000	.77000	20.000	20.000	10.000	50.000	45.000	40.000
8	12.340	12.290	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1	.10000 -1
8	1.0900	.69000						
9	2.2000	1.7900	40.000		1000.0	20.000	30.000	800.00
9	49.100	42.800	.10000 -1		9.8000	.10000 -1	.10000 -1	9.8000
9	.41000	.34000						
10	.48000		25.000	30.000	55.000			
10	1.8900		.10000 -1	.10000 -1	.10000 -1			
10	5.1000							
11	.17000	.10000 -1	0.	0.	0.	2.0000	5.0000	2.0000
11	1.7500	.28000	.10000 -1	.50000 -1	0.	.10000 -1	.50000 -1	.10000 -1
11	.33000	.17000						
12	2.7850	2.4810	780.00	270.00	735.00	215.00	235.00	140.00
12	67.060	60.830	3.6000	3.8000	2.4500	3.7000	3.8000	1.7000
12	.44000	.43000						
13	1.0400	.85000	110.00	110.00	70.000	85.000	120.00	60.000
13	5.7800	4.3700	.40000 -1	.50000 -1	.50000 -1	.10000	.10000	.10000 -1
13	.49000	.33000						
14	.96000	.51000	32.000	38.000	8.0000	320.00	30.000	15.000
14	11.350	5.6500	.50000 -1	.20000 -1	.20000 -1	.25000	.10000 -1	.10000 -1
14	1.2300	1.2000						
15	.75300	.54900	20.000	30.000	5.0000	5.0000	5.0000	5.0000
15	8.2100	7.0700	0.	.10000 -1	.10000 -1	.10000 -1	0.	0.
15	1.1900	.96000						
16	.96100	.67400	70.000	90.000	35.000	5.0000	60.000	10.000
16	6.1100	4.5900	.50000 -1	.40000 -1	.20000 -1	.10000 -1	.30000 -1	.20000 -1
16	.53000	.43000						

Numerical Results
FTP, LA 4 50-Cruise and
Two-Mode Loaded

ATTACHMENT 4

0. CASEN	17. FTPH	18. F1H	19. F2H	20. F3H	51. LA4H	52. L1H	53. L2H
0. CASEN	32. FTPC	33. F1C	34. F2C	35. F3C	63. LA4C	64. L1C	65. L2C
0. CASEN	22. FTPN	23. F1N	24. F2N	25. F3N	55. LA4N	56. L1N	57. L2N
1	.70000	203.01	6.1700	31.920	.17000	18.660	6.4400
1	8.1100	1320.0	34.600	73.800	1.0900	75.730	42.300
1	1.8300	64.100	23.420	64.800	1.6100	68.260	21.300
2	2.2900	491.42	52.570	146.55	1.9800	247.10	53.340
2	7.0100	935.60	63.970	126.64	1.5600	48.940	48.400
2	2.4000	78.940	34.980	74.450	2.1700	74.300	30.000
3	.93000	250.58	18.250	42.600	.41900	41.360	15.970
3	19.600	1857.0	447.00	242.00	9.7500	192.00	361.00
3	1.8500	64.920	5.3200	67.870	1.6800	64.680	18.250
4	1.4600	237.92	46.640	101.20	1.0700	100.60	49.240
4	24.300	1548.0	511.00	785.00	18.500	738.00	478.00
4	1.5900	47.940	23.320	40.370	1.4200	41.460	23.120
5	.72000	167.76	9.6700	46.690		63.390	
5	11.200	913.20	163.80	378.00		572.00	
5	1.9900	56.240	24.020	55.550		66.090	
6	2.8500	298.55	138.60	149.30	2.3900	175.80	133.20
6	34.100	1787.0	833.00	839.00	29.800	1041.0	865.70
6	1.7100	52.560	23.100	35.800	1.5600	45.590	20.600
7	.34000	67.100	4.4600	33.300	.20000	27.240	3.6700
7	11.350	859.00	136.00	572.00	7.9600	528.00	74.500
7	.78000	26.910	12.950	11.560	.67000	12.580	12.960
8	1.2000	287.54	11.180	79.470	.77000	112.78	8.9200
8	12.340	1142.0	102.00	519.00	12.290	807.14	120.89
8	1.0900	39.530	15.320	15.940	.69000	13.570	14.250
9	2.2000	169.95	125.64	127.62	1.7900	109.20	103.12
9	49.100	1659.0	1473.0	1337.0	42.800	1254.0	1241.0
9	.41000	22.300	4.0500	7.1500	.34000	4.6900	6.8200
10	.48000	97.540	6.7000	42.100			
10	1.8900	675.51	.97000	196.20			
10	5.1000	72.030	22.790	45.260			
11	.17000	58.920	.49000	2.5100	.10000 -1	.91000	.15000
11	1.7500	269.63	8.9600	16.260	.28000	12.120	6.0500
11	.33000	24.900	1.4200	7.7500	.17000	6.8900	1.4600
12	2.7850	269.37	139.55	183.24	2.4810	181.17	134.26
12	67.060	2944.3	1677.5	2345.6	60.830	2297.0	1573.2
12	.44000	9.5600	7.6700	8.0800	.43000	7.3300	8.5200
13	1.0400	145.21	43.290	62.050	.85000	67.720	44.710
13	5.7800	690.96	60.420	124.99	4.3700	208.38	92.710
13	.49000	29.010	3.5600	10.250	.33000	10.000	3.9100
14	.96000	181.28	26.630	57.720	.51000	48.570	21.290
14	11.360	1312.4	59.720	433.99	5.6500	417.75	27.660
14	1.2300	34.200	20.400	23.240	1.2000	27.250	20.350
15	.75300	137.69	19.470	51.230	.54900	55.880	20.580
15	8.2100	943.33	22.100	372.71	7.0700	446.25	79.260
15	1.1900	32.540	18.350	22.920	.96000	16.150	18.720
16	.96100	123.76	43.740	51.650	.67400	60.370	30.010
16	6.1100	652.91	90.960	101.44	4.5900	249.00	74.790
16	.53000	30.290	4.2100	9.5500	.43000	10.700	6.2100

Numerical Results
FTP, LA 4 and BAG Readings

ATTACHMENT 5

0.	17.	32.	22.	27.
CASEN	FIPH	FIPC	FIPM	FIP2
0.	51.	63.	55.	59.
CASEN	LAHH	LAHC	LAHM	LAH2
0.	21.	36.	26.	31.
CASEN	FIH	FIC	FIM	FI2
0.	54.	66.	59.	62.
CASEN	LIH	LIC	LIM	LI2
1	.70000	8.1100	1.8300	555.00
1	.17000	1.0700	1.8100	55.000
1	22.330	473.00	14.960	1.0300
1	40.200	777.00	21.940	1.1400
2	2.2700	7.0100	2.4000	596.00
2	1.9800	1.5600	2.1700	573.00
2	92.400	244.00	31.330	1.4720
2	73.100	141.00	36.400	1.4200
3	.93000	19.400	1.8500	566.00
3	.41000	9.7500	1.6500	553.00
3	88.800	824.00	28.400	1.4200
3	74.200	679.00	26.400	1.3500
4	1.4600	24.300	1.5900	281.00
4	1.0900	18.500	1.4200	277.00
4	62.200	694.00	8.4000	.44000
4	28.700	412.00	4.4100	.44000
5	.72000	11.200	1.9900	303.00
5				
5	12.100	125.00	7.1300	.46000
5	30.900	729.00	23.630	.75000
6	2.8500	34.100	1.7100	249.00
6	2.3900	29.800	1.5600	242.00
6	140.28	1650.0	6.7600	.34000
6	117.39	1300.0	11.250	.39000
7	.34000	11.350	.78000	459.00
7	.20000	7.9800	.67000	440.00
7	5.7000	324.00	5.4700	.86000
7	9.6900	257.00	5.4500	.85300
8	1.2000	12.340	1.0900	481.00
8	.77000	12.270	.69000	475.00
8	3.9600	315.00	8.2900	.93000
8	9.3500	312.00	7.8800	.92000
9	2.2000	49.100	.41000	418.00
9	1.7900	42.800	.34000	411.00
9	87.270	1539.0	2.1100	.82000
9	69.960	1114.0	5.2500	.72000
10	.48300	1.8900	5.1000	477.00
10				
10	30.070	188.35	33.690	1.1200
10				
11	.17000	1.7500	.33000	416.00
11	.10000 -1	.76000	.17000	371.00
11	.62000	2.9800	5.3300	.77600
11	.54300	8.4300	3.3100	.74600
12	2.7850	67.050	.44900	352.00
12	2.4810	60.830	.43000	331.00
12	147.91	2117.0	4.5600	.84200
12	130.78	2078.2	1.5200	.65500
13	1.0400	5.7890	.49900	367.00
13	.85000	4.3700	.33000	357.00
13				
13				
14	.96000	11.350	1.2300	371.00
14	.51000	5.6500	1.2000	365.00
14				
14				
15	.75300	8.2100	1.1900	381.00
15	.54920	7.0700	.96000	355.00
15	67.970	154.81	11.140	.93000
15	44.220	159.53	3.2100	.82400
16	.95100	6.1100	.53000	365.00
16	.67400	4.5800	.43000	351.00
16	54.390	55.440	2.2600	.81700
16	52.370	65.120	3.3800	.81100

Numerical Results (All Emissions)
FTP, LA 4 INCOLL

ATTACHMENT 6

0.	17.	51.	21.	54.
CASE#	FTPH	LA4H	FIH	LIH
0.	32.	63..	36.	65.
CASE#	FTPC	LA4C	FIC	LIC
0.	22.	55.	26.	58.
CASE#	FTPH	LA4H	FIH	LIH
1	0.	0.	0.	0.
1	0.	0.	0.	1.0000
1	0.	0.	0.	0.
2	1.0000	1.0000	1.0000	1.0000
2	0.	0.	0.	0.
2	1.0000	1.0000	1.0000	1.0000
3	1.0000	0.	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000
3	0.	0.	1.0000	1.0000
4	0.	0.	0.	0.
4	1.0000	1.0000	1.0000	0.
4	0.	0.	0.	0.
5	0.		0.	0.
5	0.		0.	1.0000
5	0.		0.	0.
6	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000
6	0.	0.	0.	0.
7	0.	0.	0.	0.
7	1.0000	1.0000	0.	0.
7	0.	0.	0.	0.
8	1.0000	1.0000	0.	0.
8	1.0000	1.0000	0.	0.
8	0.	0.	0.	0.
9	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000
9	0.	0.	0.	0.
10	0.		0.	
10	0.		0.	
10	1.0000		1.0000	
11	0.	0.	0.	0.
11	0.	0.	0.	0.
11	0.	0.	0.	0.
12	1.0000	1.0000	1.0000	1.0000
12	1.0000	1.0000	1.0000	1.0000
12	0.	0.	0.	0.
13	1.0000	1.0000		
13	0.	0.		
13	0.	0.		
14	1.0000	1.0000		
14	1.0000	0.		
14	1.0000	1.0000		
15	1.0000	1.0000	1.0000	0.
15	0.	0.	0.	0.
15	1.0000	0.	0.	0.
16	1.0000	1.0000	0.	0.
16	0.	0.	0.	0.
16	0.	0.	0.	0.

Pass/Fail Results
FTP, LA 4 and INCOLL METHOD 1

ATTACHMENT 7

0.	17.	51.	21.	54.
CASE#	FTPH	LA4H	FIH	LIH
0.	32.	63.	36.	66.
CASE#	FTPC	LA4C	FIC	LIC
0.	22.	55.	26.	58.
CASE#	FTPH	LA4H	FIH	LIH
1	0.	0.	0.	1.0000
1	0.	0.	1.0000	1.0000
1	0.	0.	0.	1.0000
2	1.0000	1.0000	1.0000	1.0000
2	0.	0.	0.	0.
2	1.0000	1.0000	1.0000	1.0000
3	1.0000	0.	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000
3	0.	0.	1.0000	1.0000
4	0.	0.	0.	0.
4	1.0000	1.0000	1.0000	0.
4	0.	0.	0.	0.
5	0.		0.	0.
5	0.		0.	1.0000
5	0.		0.	1.0000
6	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000
6	0.	0.	0.	0.
7	0.	0.	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000
7	0.	0.	0.	0.
8	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000
8	0.	0.	0.	0.
9	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000
9	0.	0.	0.	0.
10	0.		0.	
10	0.		0.	
10	1.0000		1.0000	
11	0.	0.	0.	0.
11	0.	0.	0.	0.
11	0.	0.	0.	0.
12	1.0000	1.0000	1.0000	1.0000
12	1.0000	1.0000	1.0000	1.0000
12	0.	0.	0.	0.
13	1.0000	1.0000		
13	0.	0.		
13	0.	0.		
14	1.0000	1.0000		
14	1.0000	0.		
14	1.0000	1.0000		
15	1.0000	1.0000	1.0000	1.0000
15	0.	0.	0.	0.
15	1.0000	0.	1.0000	0.
16	1.0000	1.0000	1.0000	1.0000
16	0.	0.	0.	0.
16	0.	0.	0.	0.

Pass/Fail Results
FTP, LA-4, INCOLL Method 2

0. CASE#	17. FTPH	51. LA4H	5. S4MI1H1	7. S4MI2H1	9. S4MI3H1	11. S4MI4H1	39. S4MI1H2	41. S4MI2H2	43. S4MI3H2	45. S4MI4H2

0. CASE#	32. FTPC	63. LA4C	6. S4MI1C1	8. S4MI2C1	10. S4MI3C1	12. S4MI4C1	40. S4MI1C2	42. S4MI2C2	44. S4MI3C2	46. S4MI4C2

0. CASE#	22. FTPH	55. LA4H

1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1	0.	0.								
2	1.0000	1.0000	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	1.0000	1.0000								
3	1.0000	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	1.0000	1.0000	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.								
4	0.	0.	1.0000	0.	1.0000		1.0000	0.	1.0000	
4	1.0000	1.0000	1.0000	0.	1.0000		1.0000	0.	1.0000	
4	0.	0.								
5	0.		0.	0.	0.		0.	0.	0.	
5	0.		0.	0.	0.		0.	0.	0.	
5	0.									
6	1.0000	1.0000	1.0000	0.	1.0000		1.0000	0.	1.0000	
6	1.0000	1.0000	1.0000	1.0000	1.0000		1.0000	1.0000	1.0000	
6	0.	0.								
7	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	1.0000	1.0000	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.								
8	1.0000	1.0000	0.	0.	0.	0.	0.	0.	0.	0.
8	1.0000	1.0000	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.								
9	1.0000	1.0000	1.0000	0.	1.0000	1.0000	1.0000	0.	1.0000	1.0000
9	1.0000	1.0000	1.0000	0.	1.0000	1.0000	1.0000	0.	1.0000	1.0000
9	0.	0.								
10	0.		0.	0.	0.	0.				
10	0.		0.	0.	0.	0.				
10	1.0000									
11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.								
12	1.0000	1.0000	1.0000	0.	0.	1.0000	0.	0.	0.	1.0000
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12	0.	0.								
13	1.0000	1.0000	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.								
14	1.0000	1.0000	0.	0.	0.	0.	0.	0.	0.	0.
14	1.0000	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	1.0000	1.0000								
15	1.0000	1.0000	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	1.0000	0.								
16	1.0000	1.0000	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.								

Pass/Fail Results
FTP, LA 4 and 4-Mode Idle

ATTACHMENT 8

0.	17.	51.	3.	13.	15.	37.	47.	49.
CASE#	FTPH	LA4H	S50CH1	S30LH1	S30IH1	S50CH2	S30LH2	S30IH2

0.	32.	63.	4.	14.	16.	38.	48.	50.
CASE#	FTPC	LA4C	S50CC1	S30LC1	S30IC1	S50CC2	S30LC2	S30IC2

0.	22.	55.
CASE#	FTPN	LA4N

1	0.	0.	0.	0.	0.	0.	0.	0.
1	0.	0.	0.	0.	0.	0.	0.	0.
1	0.	0.						
2	1.0000	1.0000	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.
2	1.0000	1.0000						
3	1.0000	0.	0.	0.	0.	0.	0.	0.
3	1.0000	1.0000	0.	0.	0.	0.	0.	0.
3	0.	0.						
4	0.	0.	0.	0.	1.0000	0.	0.	1.0000
4	1.0000	1.0000	0.	0.	1.0000	0.	0.	1.0000
4	0.	0.						
5	0.		0.	0.	0.	0.	0.	0.
5	0.		0.	0.	0.	0.	0.	0.
5	0.							
6	1.0000	1.0000	0.	0.	1.0000	0.	0.	1.0000
6	1.0000	1.0000	0.	0.	1.0000	0.	0.	1.0000
6	0.	0.						
7	0.	0.	0.	0.	0.	0.	0.	0.
7	1.0000	1.0000	0.	0.	0.	0.	0.	0.
7	0.	0.						
8	1.0000	1.0000	0.	0.	0.	0.	0.	0.
8	1.0000	1.0000	0.	0.	0.	0.	0.	0.
8	0.	0.						
9	1.0000	1.0000	0.		1.0000	0.	0.	1.0000
9	1.0000	1.0000	0.		1.0000	0.	0.	1.0000
9	0.	0.						
10	0.		0.	0.	0.			
10	0.		0.	0.	0.			
10	1.0000							
11	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.						
12	1.0000	1.0000	1.0000	1.0000	1.0000	0.	1.0000	0.
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12	0.	0.						
13	1.0000	1.0000	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.						
14	1.0000	1.0000	0.	0.	0.	1.0000	0.	0.
14	1.0000	0.	0.	0.	0.	0.	0.	0.
14	1.0000	1.0000						
15	1.0000	1.0000	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.
15	1.0000	0.						
16	1.0000	1.0000	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.						

Pass/Fail Results
FTP, LA 4, 50-Cruise and
2-Mode Loaded

ATTACHMENT 9