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March 11, 1992

Mr. Morton J. Getman
The Society of Automotive Vehicle Emissions Reduction, Inc.
166 Washington Avenue
Albany, New York 12210

Dear Mort:

We have recently completed an evaluation of the 1988 Sierra Research paper that serves as the basis for our testing of an enhanced BAR '90 emissions test. I am forwarding a copy of this evaluation to you for your information. A copy of this paper has also been delivered to the USEPA (Dick Wilson), the API (Fuels Task Force), CARB (Tom Cackette), BAR (Jim Shonig), and CA Sen Presley (Carla Anderson).

In addition to visiting with the USEPA last week, I also delivered our enhanced I/M position to the API Fuels Task Force (I understand that they have been assigned this issue for API). Our comments were presented from the point-of-view that while the USEPA was promoting IM240 as a means to reduce mobile emissions by as much as 30%, we weren't likely to see the 30% reductions due to the imbalanced nature of the USEPA's approach; high-tech inspection and low-tech repairs. The Task Force seemed to be very intrigued by our view point and our alternative enhanced BAR '90 inspection methodology.

Also enclosed is a copy of some slides used by "Resources for the Future" at a recent seminar on this matter which was sponsored by them. As you can see, they are also questioning the USEPA's IM240 approach.

Sincerely,

James S. White

JSW/mac

Enhanced I/M Program
Steady State Testing vs. Transient Testing

ARCO's Analysis of the Sierra Research Report, "An Evaluation of Loaded Mode I/M Testing at Service Stations" December 7, 1988

ARCO Position:

A steady state dynamometer test, using retrofitted California BAR90 emissions analyzers, can be as effective as the proposed EPA IM240 test at a much lower cost.

Review of Sierra Research Data:

Background:

In 1988, the California Bureau of Automotive Repair contracted with Sierra Research to develop a new enhanced I/M test program that would include NO_x emissions. The results of this work were reported in the Sierra Research publication identified above and in SAE. Technical Paper #891120, "Development of Improved Loaded Mode Test Procedures for Inspection and Maintenance Programs." Because of the current development of new, enhanced I/M programs by the US EPA and California Air Resources Board, ARCO provides a new analysis of this data.

ARCO's Discussion of Results:

The data analysis done by Sierra Research evaluated the degree of fit for correlations developed between the potential test conditions explored as candidates for I/M testing and the Federal Test Procedure (FTP). This approach is useful for selecting which test conditions best relate to the FTP, which was the objective of Sierra Research in this research. However, correlations are not the best approach to use when comparing the candidates for how well they identify cars that need repair work to lower their tailpipe emissions, which is a pass/fail situation.

In this paper, each test condition was evaluated for how well it failed cars that were identified by the FTP test as excessive emitters. Emission "standards" were selected that would fail approximately 1/3 of the cars tested. These "standards" were selected for demonstration purposes only and could have been set at higher or lower levels, which would have failed fewer or more cars, respectively. Each test condition was then evaluated for those cars which would pass using this test condition, but were identified as exceeding the standard by the FTP test (False Pass). This condition is identified as quadrant #4 in the figures attached. The efficiency of each test condition is defined as 100% minus the percentage of emissions in excess of the standard (as identified by the FTP) that were falsely passed by the alternate test. 100% efficiency would mean that there were no False Passes.

Using this efficiency measurement, Table 1 compares the efficiency of each test condition (determined to be a good predictor of FTP emissions) with the FTP test and its Bag 3 component. In this analysis, Bag 3 was used as a proxy for the IM240 test because of the similarity in these two tests. The results show that the transient test (Bag 3) only identifies about 85% of the excess emissions (as measured by the FTP) for HC. The steady state conditions identify an equivalent level of excess HC emissions, in the range of 83% to 87%.

For CO, the Bag 3 test identified 85% of the excess emissions identified by the FTP test. The 35mph/light grade test condition was equally as effective (88%), while the 2500 rpm/no load condition (95%) was clearly superior to the Bag 3 test in identifying excess CO emissions.

The Bag 3 test was equivalent to the FTP (99.7%) in identifying excessive NOx emissions. The steady state test at 15 mph/medium grade was not quite as efficient, identifying 89% of the excess NOx emissions.

The best results obtained with the steady state tests were compared with the Bag 3 test results in Table 2. This "Report Card" shows that when compared to the transient test, the steady state tests are equivalent for HC, somewhat superior for CO and slightly inferior for NOx.

Another way to analyze the Sierra Research data is to determine the sensitivities of the various test conditions to the malfunctions introduced to the emission systems of the test cars. If for each car the emissions after the malfunction is introduced are compared to the baseline emissions, the sensitivity of that test condition to a malfunction can be evaluated. A malfunction was considered as being identified by a test if the emissions were increased by at least 25% by the introduction of a malfunction.

Table 3 shows the results of this analysis. On the basis of the HC emissions, the Combined Steady State tests identified 57% of the malfunctions, which was equivalent to the FTP test. The Bag 3 test was somewhat more effective in this regard due to one car which had several malfunctions introduced that were only detected by the Bag 3 test. This superiority of Bag 3 is apparently a function of the small sample size tested in this program.

For CO the Bag 3 test and the Combined Steady State tests were equivalent at identifying malfunctions and both were not as effective as the FTP. This is likely due to the fact that CO is mostly a function of Bag 1 in the FTP.

For NOx, the Steady State tests were more effective in identifying the malfunctions than were either the FTP or Bag 3 tests.

Conclusions:

The Sierra Research data is an indication that Steady State Testing can be used for I/M tailpipe testing in lieu of a transient test such as the US EPA's proposed IM240 test. When compared to the transient test method, Steady State Testing is equivalent for HC, superior for CO and nearly equivalent for NOx.

Future ARCO Work:

In order to validate these conclusions, ARCO is preparing to evaluate Steady State testing relative to the proposed IM240 test in late model California automobiles. Emission system malfunctions will be introduced to simulate cars that should fail an I/M test. Evaporative system cannister purge testing will be conducted in addition to measuring the tailpipe emissions. Results of this testing should be available by the end of March.

ARCO I/M Test Program
Schedule

March 23	*Vehicle Testing Begins at Southwest Research Institute*
March 27	*Testing Completed*
April 6	*First Analysis of Data Completed*
May 4	*Final Report*

Table 1

EFFICIENCY OF PROPOSED I/M TEST CONDITIONS RELATIVE TO FTP

	BAG 3 TEST	STEADY STATE TESTING			
		2500 rpm NO LOAD	35 mph LIGHT GRADE	15 mph MED GRADE	COMBINED*
HC	84%	83%	82%		87%
CO	85%	95%	88%		95%
NO_x	99.7%			89%	

*Combinations Used:

HC = Idle & 2500 rpm & 15 mph/med. grade
CO = 2500 rpm & 25 mph/light grades

Table 2

STEADY STATE TEST "REPORT CARD" RELATIVE TO TRANSIENT TEST

EFFICIENCY IDENTIFYING EXCESS EMISSIONS

HC	CO	NO_x
103%	111%	89%
Equivalent	Slightly Superior	Slightly Inferior

Table 3

ACCURACY IN DETECTING MALFUNCTIONS

	FTP	BAG 3	IDLE NO LOAD	2500rpm NO LOAD	35 mph LT GRADE	15 mph MED GRADE	COMB*
HC	57%	68%	47%	50%	37%		57%
CO	71%	50%	26%	35%	27%		47%
NO^x	57%	59%	0%		70%	60%	80%

***Combinations Used:**

HC = Idle & 2500 rpm
CO = 2500 rpm & 25 mph/light grade
NO_x = ASM 2535 & 15 mph/med. grade

Figure 1

HC - 2500 rpm vs. FTP

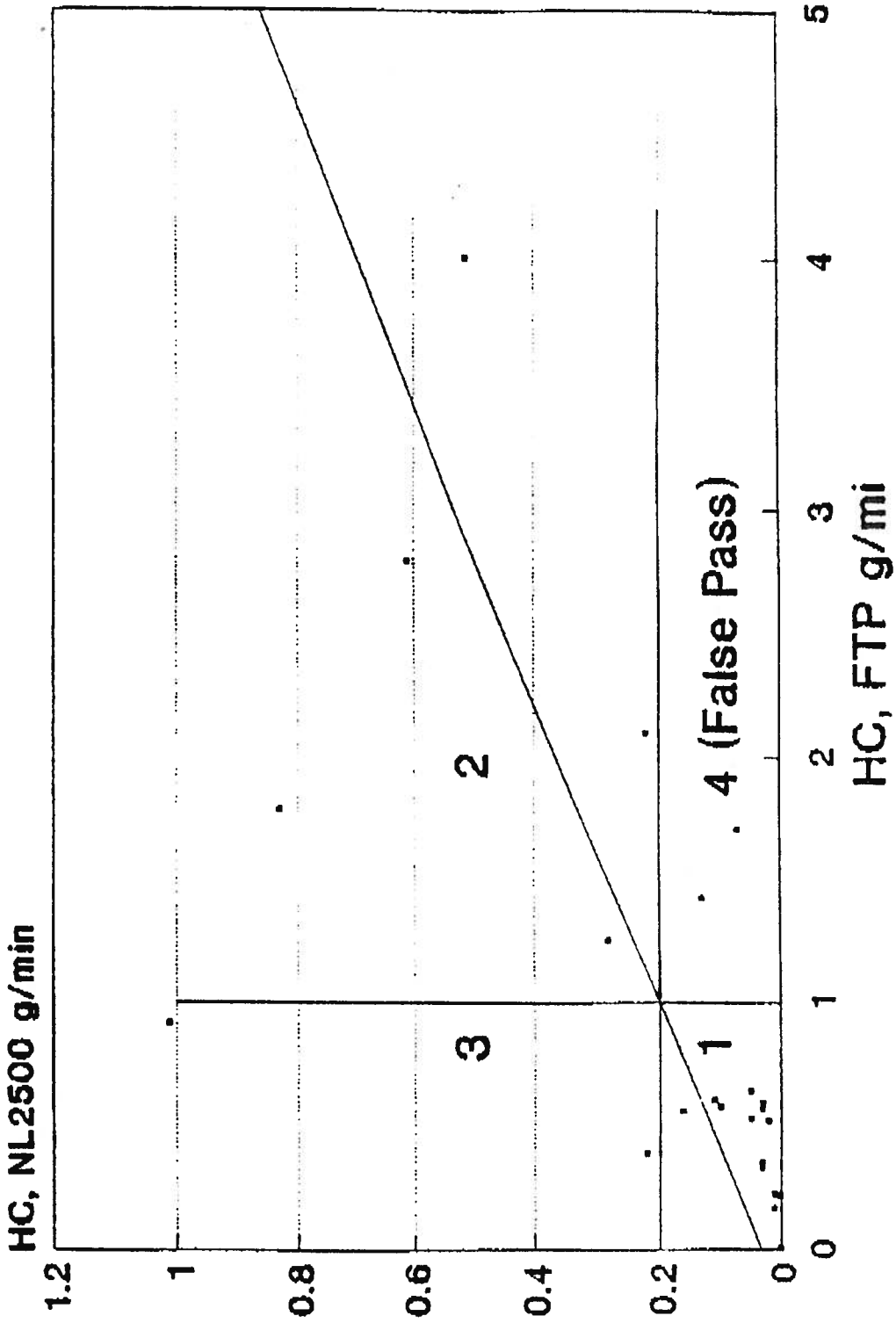

Figure 2

HC - 35mph/Light Grade vs. FTP

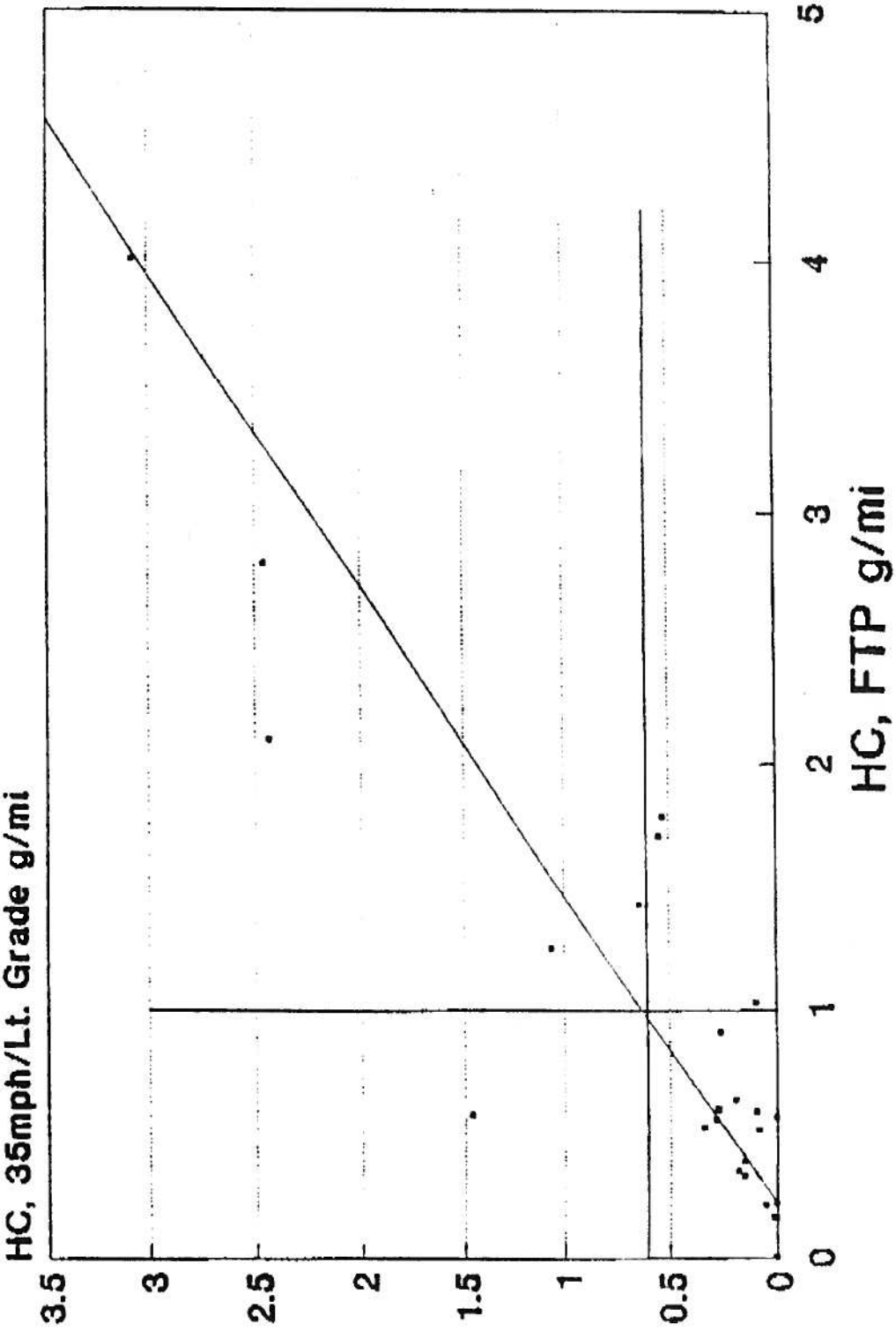

Figure 3

HC - Regressed Value vs. FTP

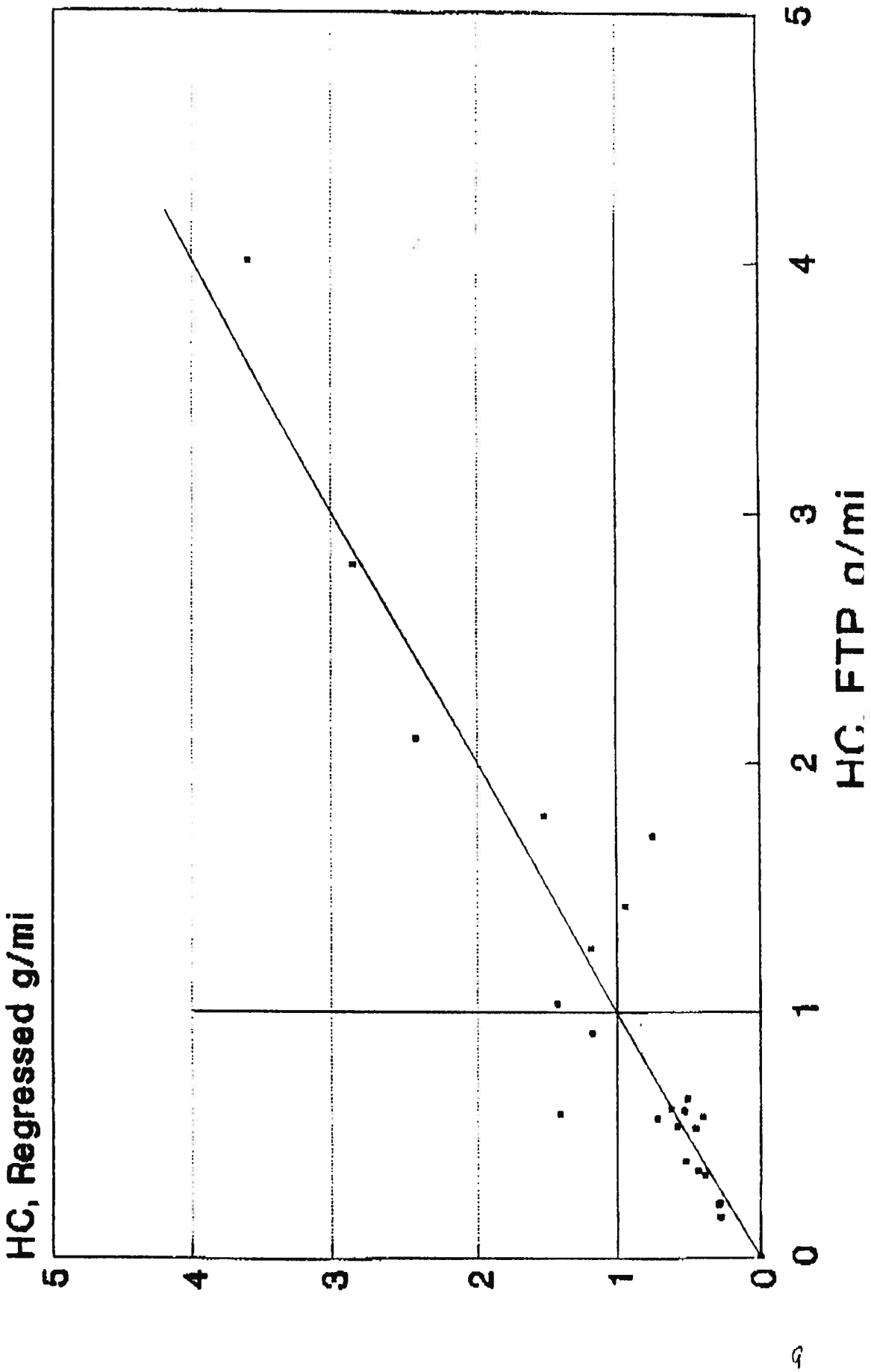

Figure 4

HC - Bag 3 vs. FTP

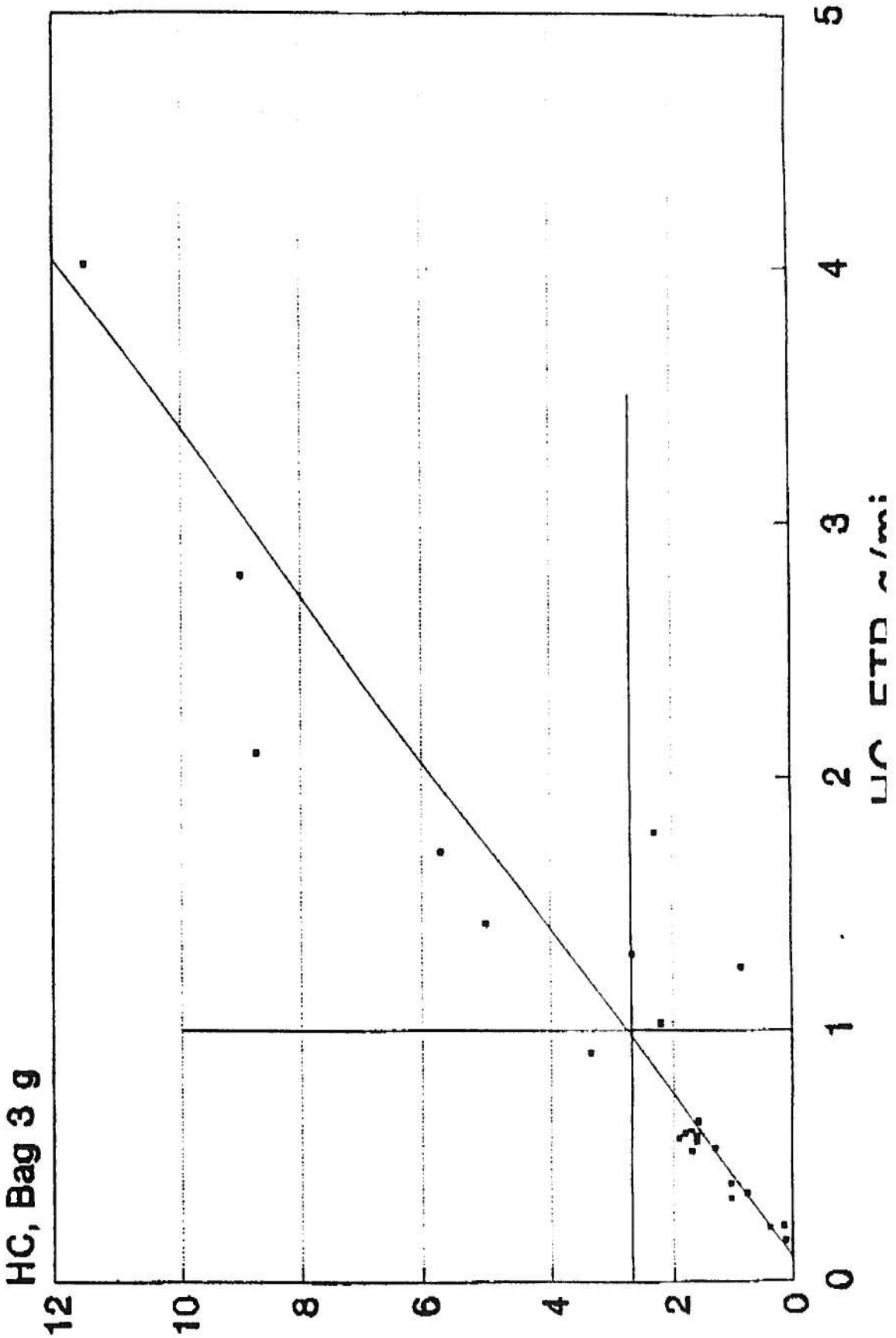

Figure 5

CO - 2500 rpm/No Load vs. FTP

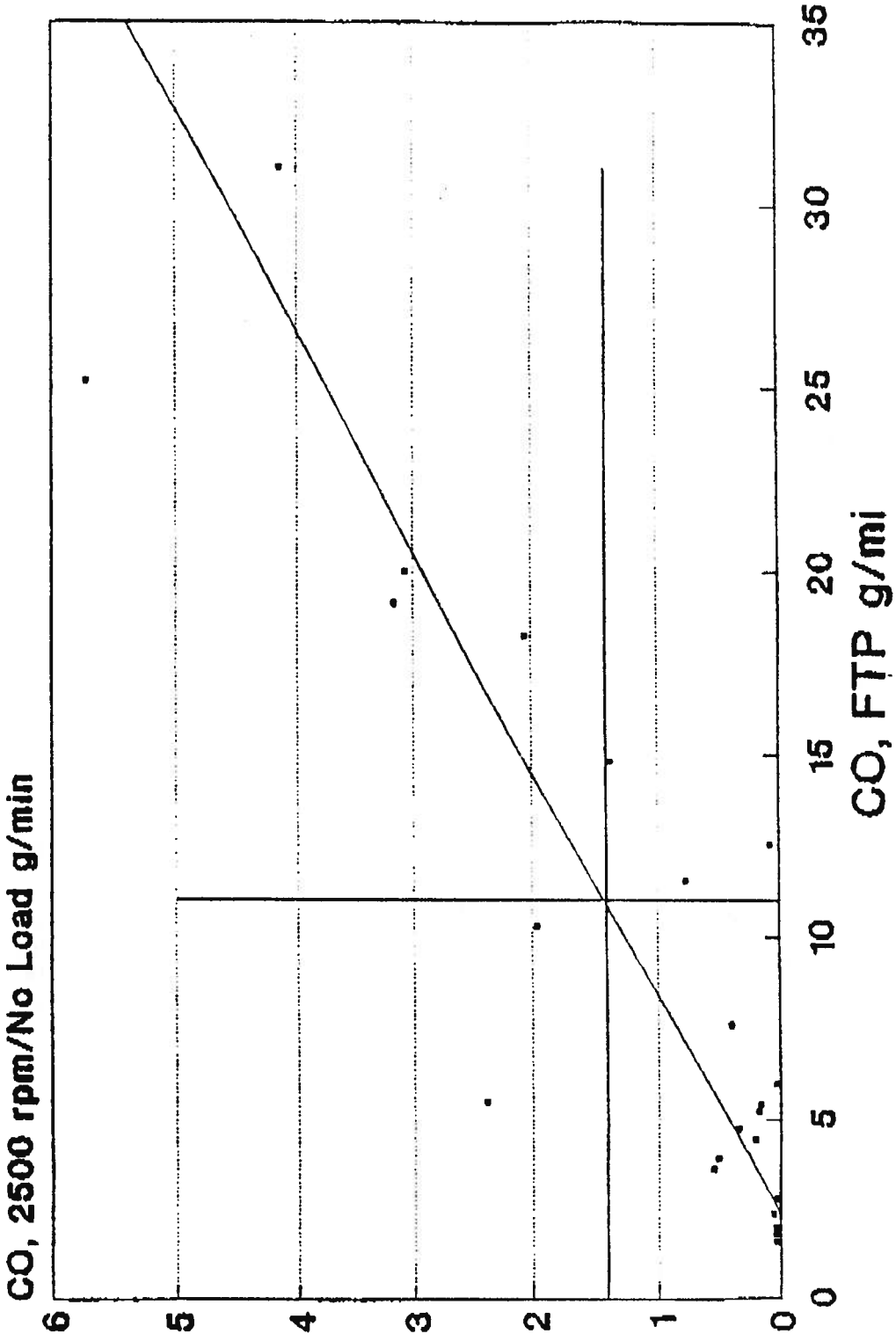

Figure 6

CO - 35mph/Light Grade vs. FTP

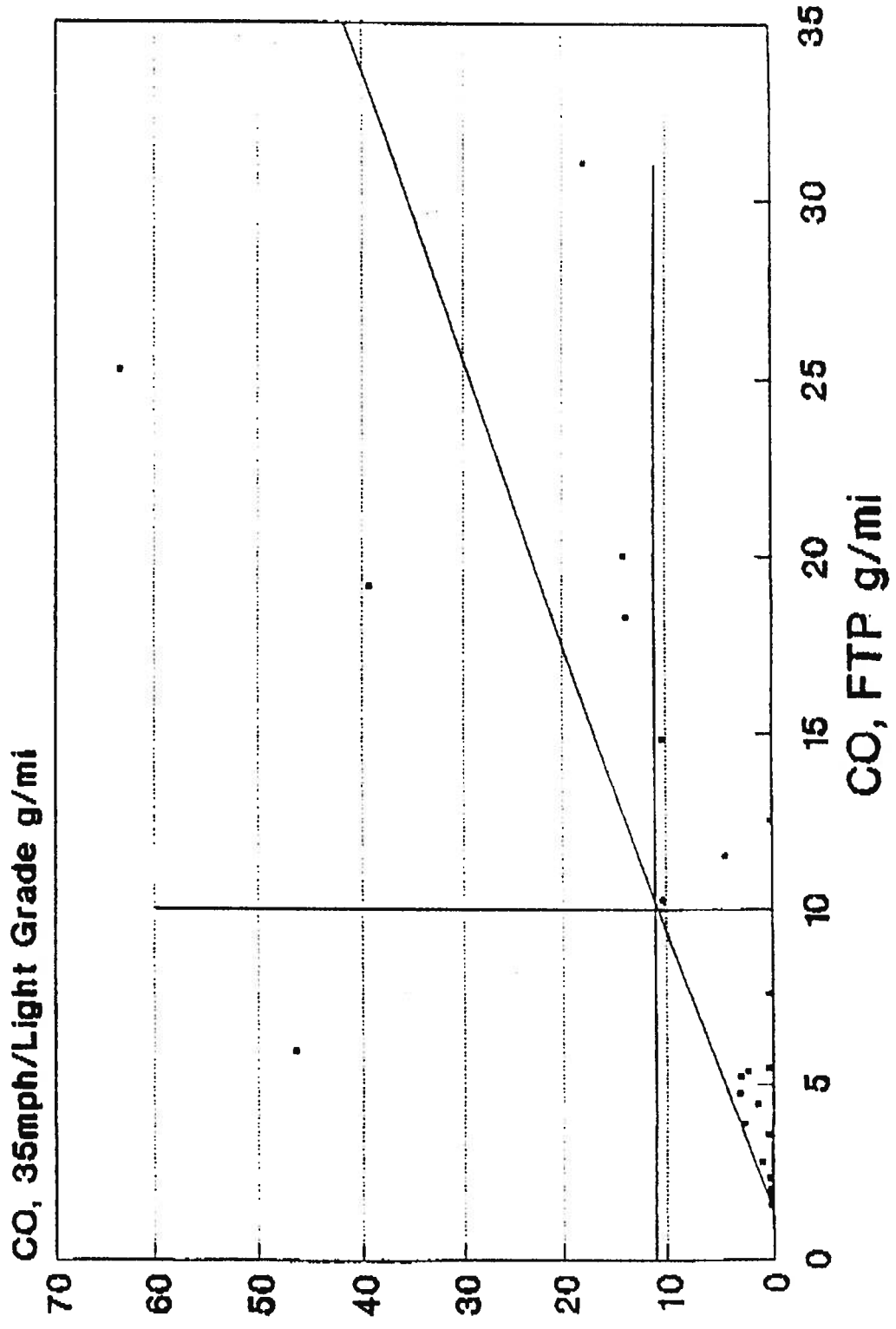

Figure 7

CO - Regressed Value vs. FTP

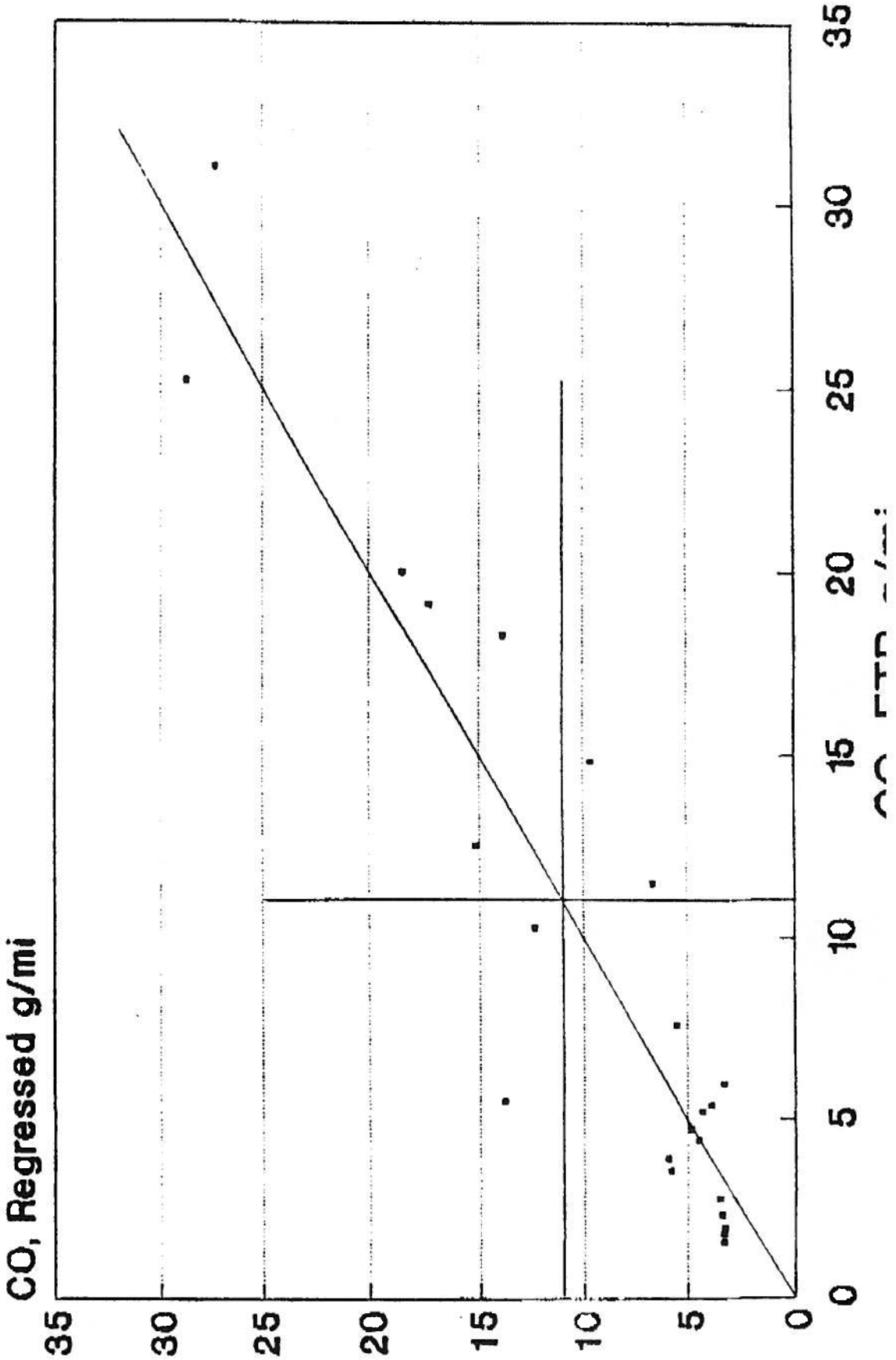

Figure 8

CO - Bag 3 vs. FTP

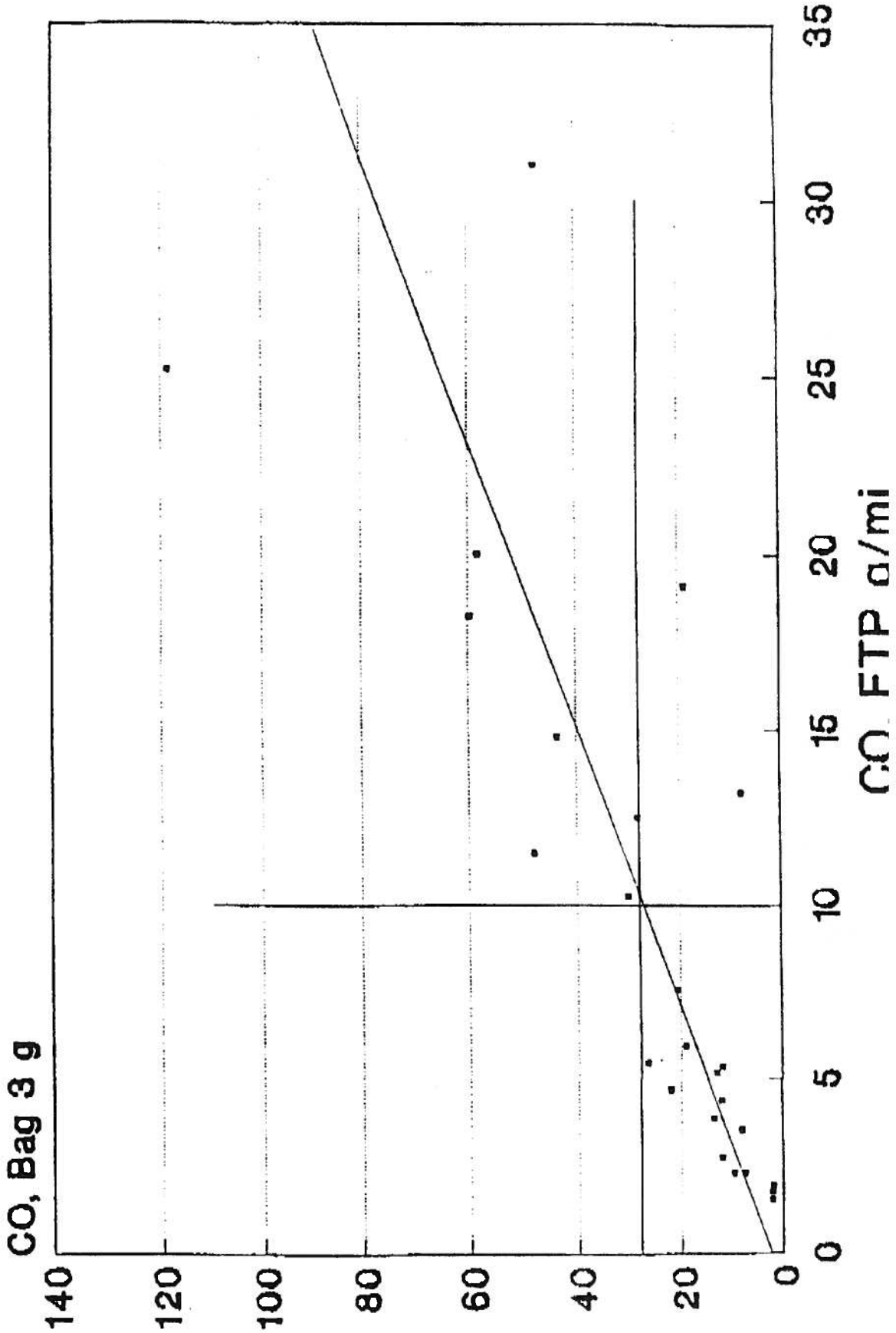

Figure 9

NOx - 15mph/Med. Grade

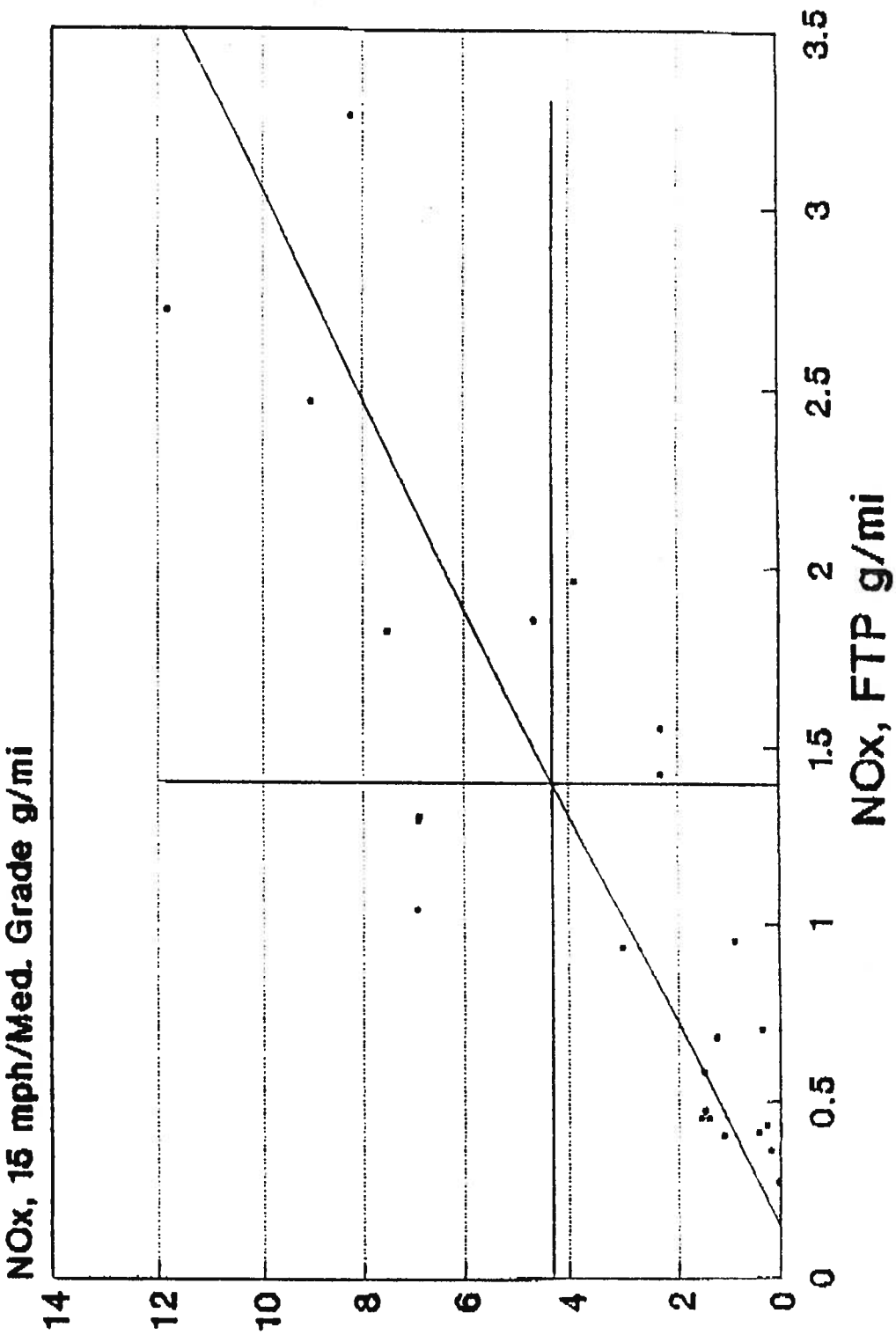

Figure 10

NOx - Bag 3 vs. FTP