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Analysis of In-House I/M Testing of a Three-Way Chevrolet Citation and a Three-Way Dodge Aspen

January, 1980

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I. INTRODUCTION

This report is an analysis of the effectiveness of I/M-type "short tests" in identifying grossly emitting vehicles. Specifically, this report examines the question for two vehicles equipped with the technology to be introduced nationwide in 1981. This technology incorporates a high degree of engine control through the use of sensors, actuators and an on-board computer, and allows the simultaneous conversion of HC, CO and NOx in a three-way catalyst.

In a testing program performed in-house at the Motor Vehicle Emission Laboratory, Ann Arbor, Michigan, a 1980 Chevrolet Citation and a 1979 Dodge Aspen were selectively disabled to simulate possible in-use vehicle conditions. A wide range of testing was performed at each condition including FTP testing and I/M short tests. In this report, the FTP results will be compared to the results of two I/M tests to examine their effectiveness in identifying vehicles with gross FTP emissions. Each vehicle will first be discussed separately and then an overall comparison will be given. Performance of the two tests using the recently proposed 207(b) cutpoints will be evaluated separately in Section IV. Full data sets for the two vehicles can be obtained from the reports referenced at the end of this report.

II. 1980 CHEVROLET CITATION

A. Vehicle Description

The Citation was equipped with a 2.5 liter L-4 engine and the General Motors "C-4" emission control system. The C-4 system incorporates an oxygen sensor, digital on-board computer, and a solenoid operated feedback carburetor. The Citation is equipped with EGR and a single three-way catalyst for the conversion of HC, CO, and NOx. It is calibrated to meet the 1980 California standards of 0.41/9.0/1.0.

B. Analysis

For the Citation, the emissions from seven distinct vehicle conditions were examined. The I/M tests were performed twice for each condition. Two baseline test sequences were performed at the beginning and the end of the test program. Three of the seven vehicle conditions had gross FTP HC and CO emissions. These were:

- Mixture control solenoid disconnected
- Mixture control solenoid disconnected and EGR disconnected.
- Oxygen sensor disconnected and lead short-circuited.

The other vehicle conditions resulted in low FTP HC and CO emissions and involved disconnecting such things as the coolant temperature switch, the EGR valve, the closed throttle switch, and the oxygen sensor (without short-circuiting the lead).

To examine how well the I/M tests could identify the grossly emitting vehicle conditions, the FTP emissions were plotted against the I/M test's emissions. For the Citation, these plots can be seen in Figures 1-4. To be a successful screen in identifying gross emitters, while not falsely identifying clean cars, an I/M test should yield values which roughly correlate with the FTP emissions. Therefore, for a successful test, plots such as Figures 1-4 should have a cloud of points in the lower left hand corner from the "clean" cars and a cloud of points in the upper right hand corner from the grossly emitting cars. Conversely, any point in the upper left hand corner (above an I/M test's cutpoint and below the FTP standard) would represent an error of commission (i.e. a falsely identified vehicle) and any point in the lower right hand corner (below the I/M cutpoint and above the line representing gross FTP emissions) would represent an error of omission (i.e. a vehicle with high enough FTP emissions to warrant identification in an I/M program). Vehicles would routinely be tested for both HC and CO, and failure for either pollutant (i.e. emissions above a selected cutpoint) would be sufficient to identify the vehicle as needing maintenance.

As can be seen in Figures 1-4, both the Loaded Two Mode test and the non-loaded Two Speed Idle test were successful in identifying the gross emitters. The scatter of points for the two tests are very similar, the chief difference being that the emissions from the 2500 rpm mode of the Two Speed Idle test were somewhat lower than all the other modes. These emissions from the 2500 rpm mode are not normally used as a criterion for evaluating whether or not a car would pass or fail an I/M test.

It is also clearly evident that no errors of commission or omission would result from either test. This is based on cutpoints of 1% CO and 100 ppm HC and assumes the emissions from the 2500 rpm mode of the Two Speed Idle test are not essential in determining failure as discussed above.

III. 1979 DODGE ASPEN

A. Vehicle Description

The Aspen was equipped with a 225 CID engine, EGR, a vacuum operated feedback carburetor, an oxygen sensor, an on-board computer and a three-way catalyst for the conversion of HC, CO, and NOx. The Aspen was also equipped with an oxidation catalyst and an air pump to provide additional HC and CO control. It was designed to meet the 1979 California standards of 0.41/9.0/1.5.

B. Analysis

For the Aspen, the emissions from five distinct vehicle conditions were evaluated as well as two baseline tests at the beginning of the program and one baseline test at the end of the program. The five vehicle conditions were:

- oxygen sensor disconnected
- coolant temperature sensor disconnected
- mixture control vacuum solenoid disconnected
- air injection bypassed
- EGR disconnected

As with the Citation, two sets of I/M tests were run for each condition. Unlike the Citation, however, none of the conditions had truly gross FTP HC and CO emissions. Even those conditions which involved a loss of feedback control did not result in high HC/CO emissions on either the FTP or the I/M tests. This is due primarily to the additional oxidation capacity provided by the extra oxidation catalyst in series with the three-way catalyst. This oxidation catalyst is supplied with oxygen by an air pump which leans out the exhaust stream in the oxidation catalyst even when a rich mixture is being provided by the carburetor. Thus, the catalyst is better able to deal with the higher levels of HC and CO which would normally result from a loss of engine feedback control. The only vehicle condition with emissions significantly above the standard is that with the air pump disconnected (FTP HC = 1.03 gm/mi, FTP CO = 29.8 gm/mi). This underlines the issue discussed above, that is, with the air pump disabled and much of the additional oxidation capacity lost, the Aspen's emission performance begins to resemble the Citation's more closely.

As with the Citation, the I/M test's emissions were plotted against the FTP emissions. It is important to note the different scales used on these plots as opposed to the Citation's plots. Both the I/M emissions and the FTP emissions have different scales. These plots can be seen in Figures 5-8.

As can be seen in Figures 5-8, the single vehicle condition with higher FTP emission levels was essentially separated from the other points. This is especially true for CO (Figures 5 and 7). It is important to note, however, that a relatively low I/M cutpoint would have been needed to identify this car as needing maintenance (approximately .5% CO). For HC, the FTP emissions for the one higher condition were not as grossly above standards as for the FTP CO emissions, and the corresponding I/M tests' emission levels were also not as high. As can be seen in Figures 6 and 8, however, the emission levels at <u>idle</u> were essentially separate for the one higher point.

As can also be seen in Figures 6 and 8, one point (representing a disconnected EGR with FTP HC emissions at 0.4 gm/mi and with I/M tests' emissions of 70 ppm and 90 ppm for the Loaded Two Mode and the Two Speed Idle respectively), could possibly have caused an error of commission. This would depend of course on the I/M cutpoint used.

One data point for the Aspen was dropped as it was an apparent data collection error.

IV. PERFORMANCE OF THE TWO I/M TESTS USING 207(b) CUTPOINTS

A. Description of 207(b) Cutpoints

Section 207(b) of the Clean Air Act provides for the establishment of I/M cutpoints which could be used in warranty claims against the auto manufacturers. In this portion of the report, the currently proposed cutpoints (Reference 3) will be applied to the data from the Aspen and the Citation.

For the Two Speed Idle test, the 207(b) cutpoints are 1.0% CO and 200 ppm HC. The lower of the emission levels from the two idle modes and/or the emission levels from the 2500 rpm mode can be selected as the criteria by a state or municipality to determine whether or not a vehicle passed the test. Thus, the idle emissions alone, the 2500 rpm emissions alone, or the two combined can be used as a basis for decision. It is also important to note that if a vehicle fails any section of the test and for either CO or HC, it fails the whole test.

For the Loaded Two Mode test, the cutpoints are 1.2% CO and 220 ppm HC for both modes of the test. Here too, a state or municipality can choose the emissions from either or both of the modes as the basis for decision, and if a vehicle fails any section of the test for either CO or HC, it fails the whole test.

B. 1980 Citation

For the Citation, both the Loaded Two Mode test and the Two Speed Idle test demonstrated perfect performance (i.e. no errors of commission or errors of omission) using the 207(b) cutpoints in all possible configurations of the test criteria. All of the failures were for high CO levels.

C. 1979 Dodge Aspen

For the Aspen, none of the I/M tests' emissions were above the 207(b) cutpoints, so there were therefore no errors of commission possible. The failure rate for correctly identified vehicles was also therefore zero.

In looking at errors of omission, points to the right of (i.e. above) the FTP standard in Figures 5-8 must be identified. For the Aspen, the applicable standards are 0.41/9.0/1.5 for 1979 California vehicles. Using these standards, three of the eight vehicle conditions could be called "errors of omission", however in terms of significance, only the vehicle condition with the disconnected air pump could be termed a significant error of omission. The other two conditions had FTP emissions only marginally over the standard.

In summary then, analysis of the Aspen's emissions using 207(b) cutpoints is inconclusive, since to properly evaluate the issue, a wider spread of data would be needed. There were no errors of commission and there was one significant error of omission.

V. CONCLUSIONS

Both the Loaded Two Mode and the Two Speed Idle tests demonstrated their ability to identify the grossly emitting vehicle conditions. This depends of course on the cutpoints used and what is defined as grossly emitting. For CO, the issue is clear, and especially so for the grossly emitting conditions from the Citation. For HC, the issue is clear for the Citation and somewhat clouded for the Aspen. In general, the results from the Aspen are of limited value, since the central question involves whether I/M tests can identify gross emitters or not, and the Aspen had generally very clean emissions. One thing that can be said for both the Citation and the Aspen is that the vehicle conditions with low FTP emissions also had low I/M test emissions, i.e., there were no significant errors of commission. This is especially true for CO and generally true for HC except for the one questionable point from the Aspen discussed above.

References:

1. Evaluation of Applicability of Inspection/Maintenance Tests on a Dodge Aspen Prototype. August 1979, Thomas J. Penninga, Technology Assessment and Evaluation Branch, Emission Control Technology Division, OANR, U.S. EPA.

2. Evaluation of Applicability of Inspection/Maintenance Tests on a Chevrolet Citation. October 1979, Thomas J. Penninga. Technology Assessment and Evaluation Branch, Emission Control Technology Division, OANR, U.S. EPA.

3. Light Duty Vehicle and Light Duty Truck Emission Performance Warranty; Short Tests and Standards. December 1979, Inspection/Maintenance Staff, Emission Control Technology Division, OANR, U.S. EPA.

Figure 1

CITATION

FTP CO vs. Loaded Two Mode CO

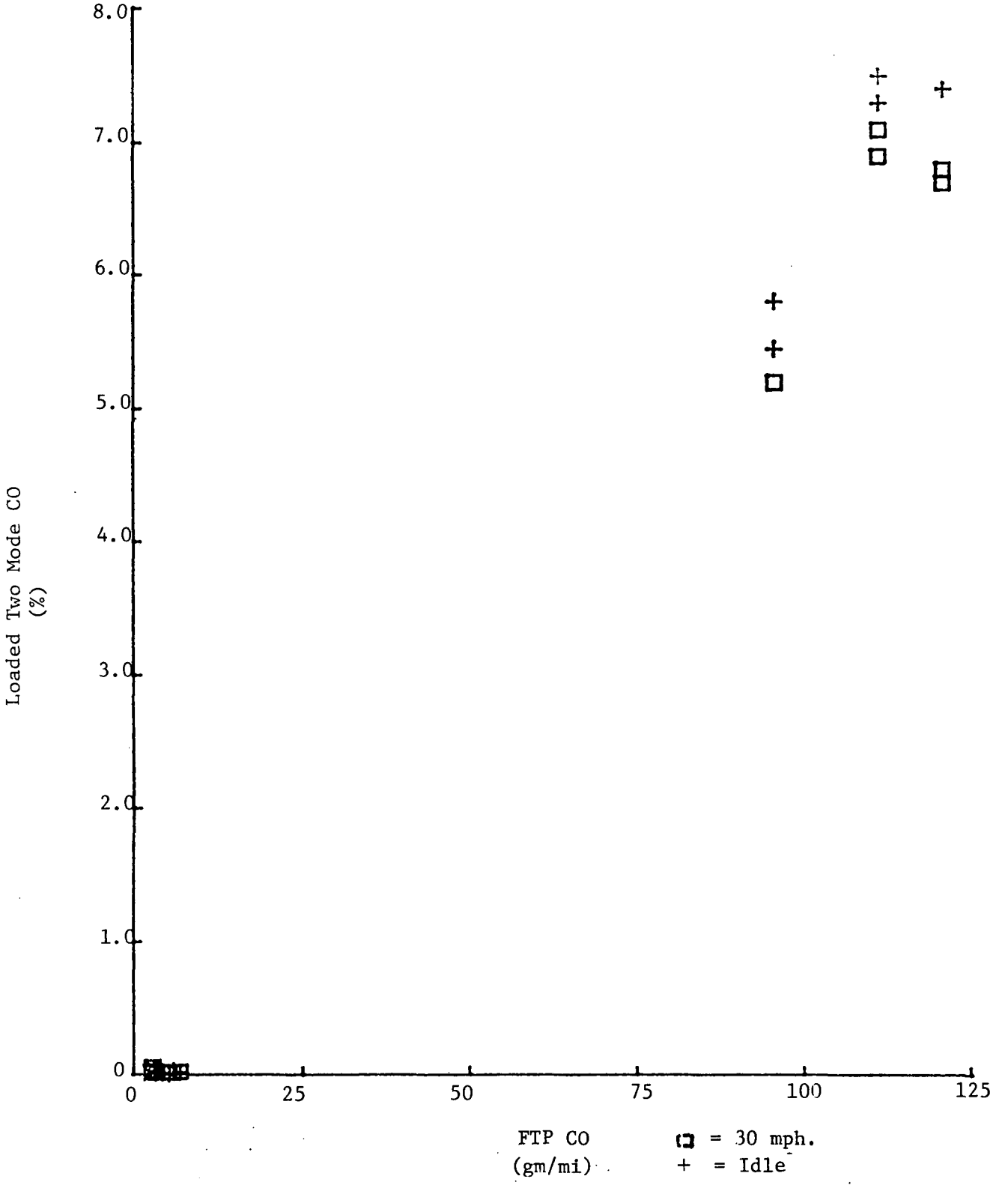


Figure 2

CITATION

FTP HC vs. Loaded Two Mode HC

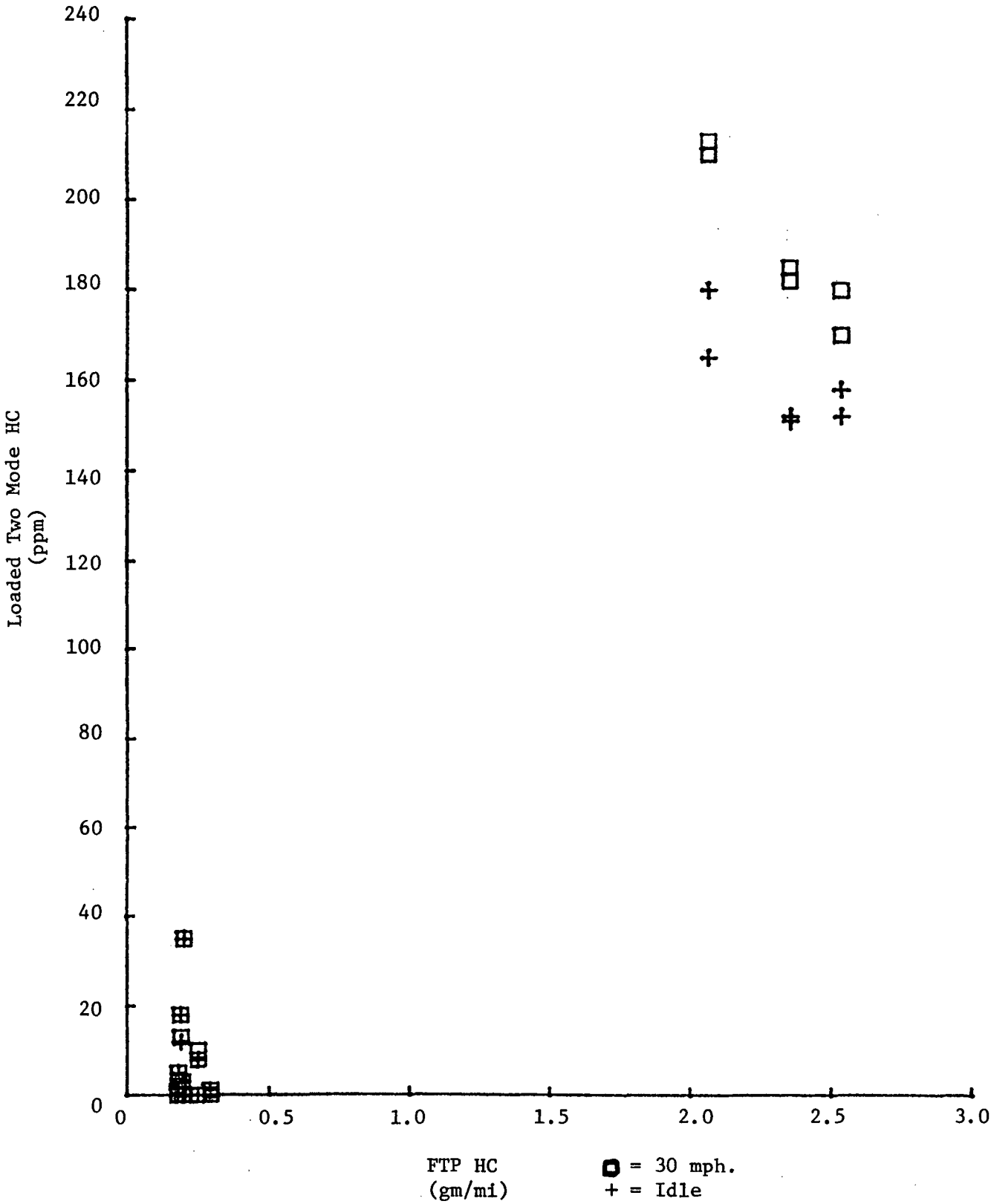


Figure 3

CITATION

FTP CO vs. Two Speed Idle CO

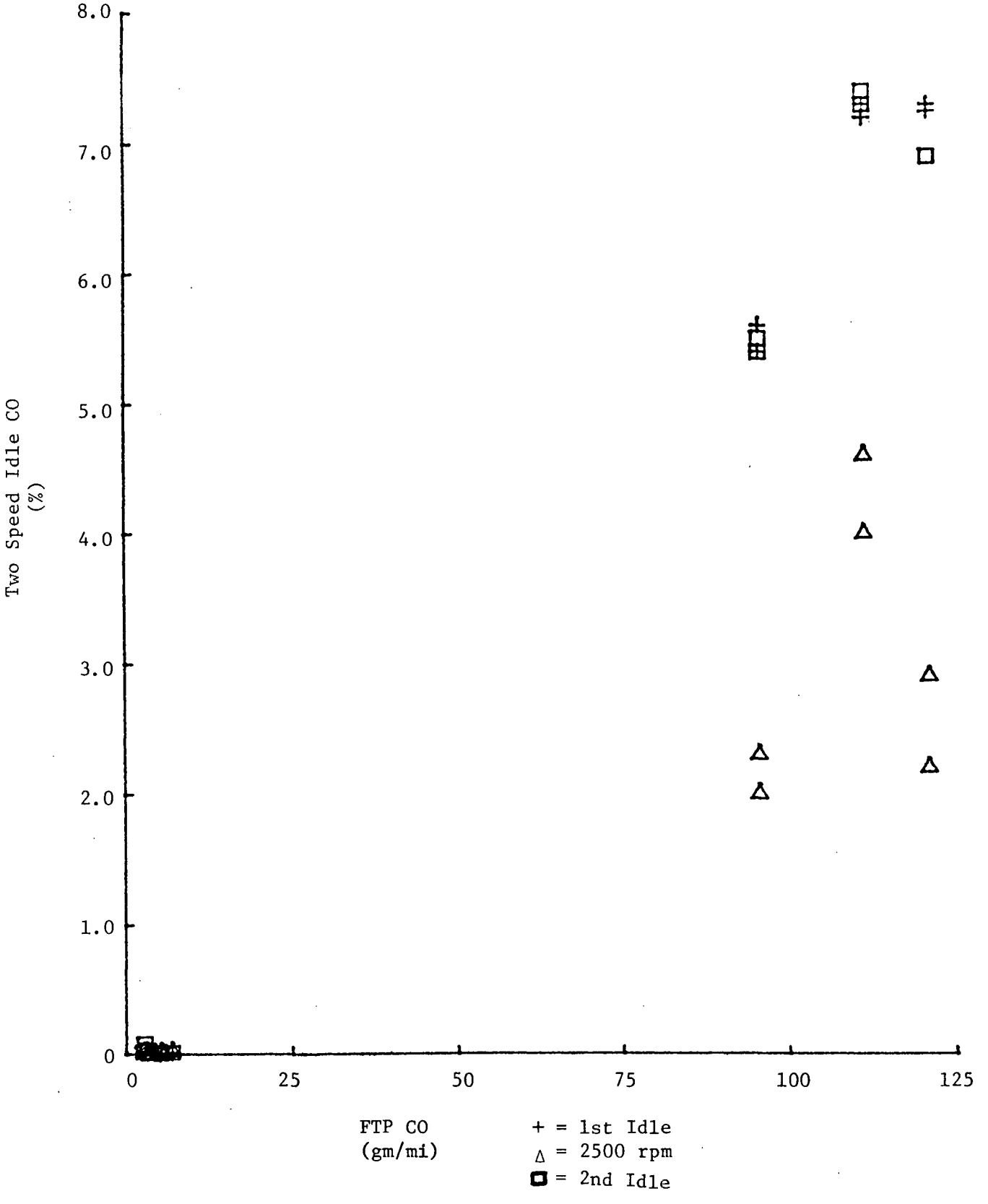


Figure 4

CITATION

FTP HC vs. Two Speed Idle HC

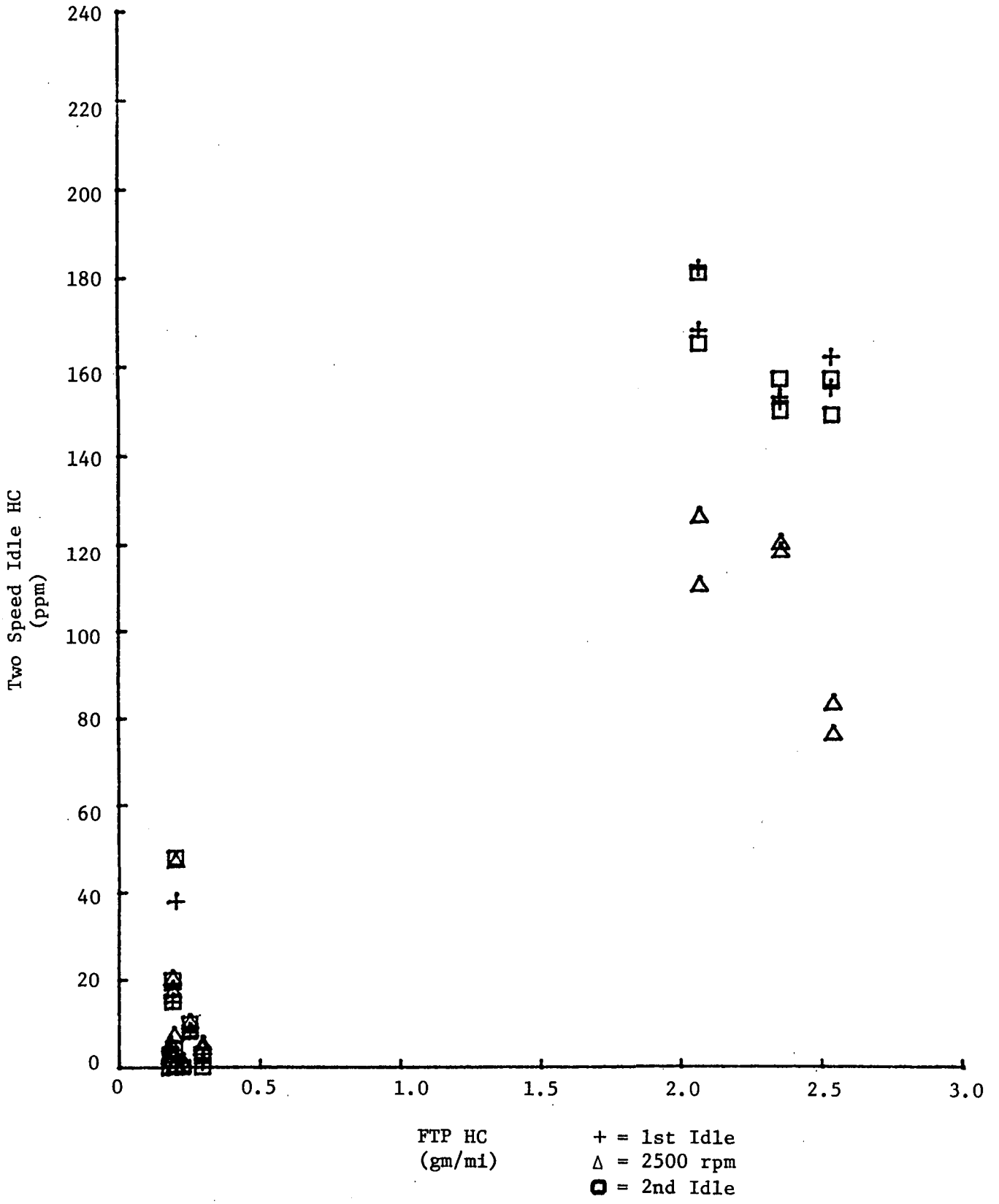


Figure 5

ASPEN

FTP CO vs. Loaded Two Mode CO

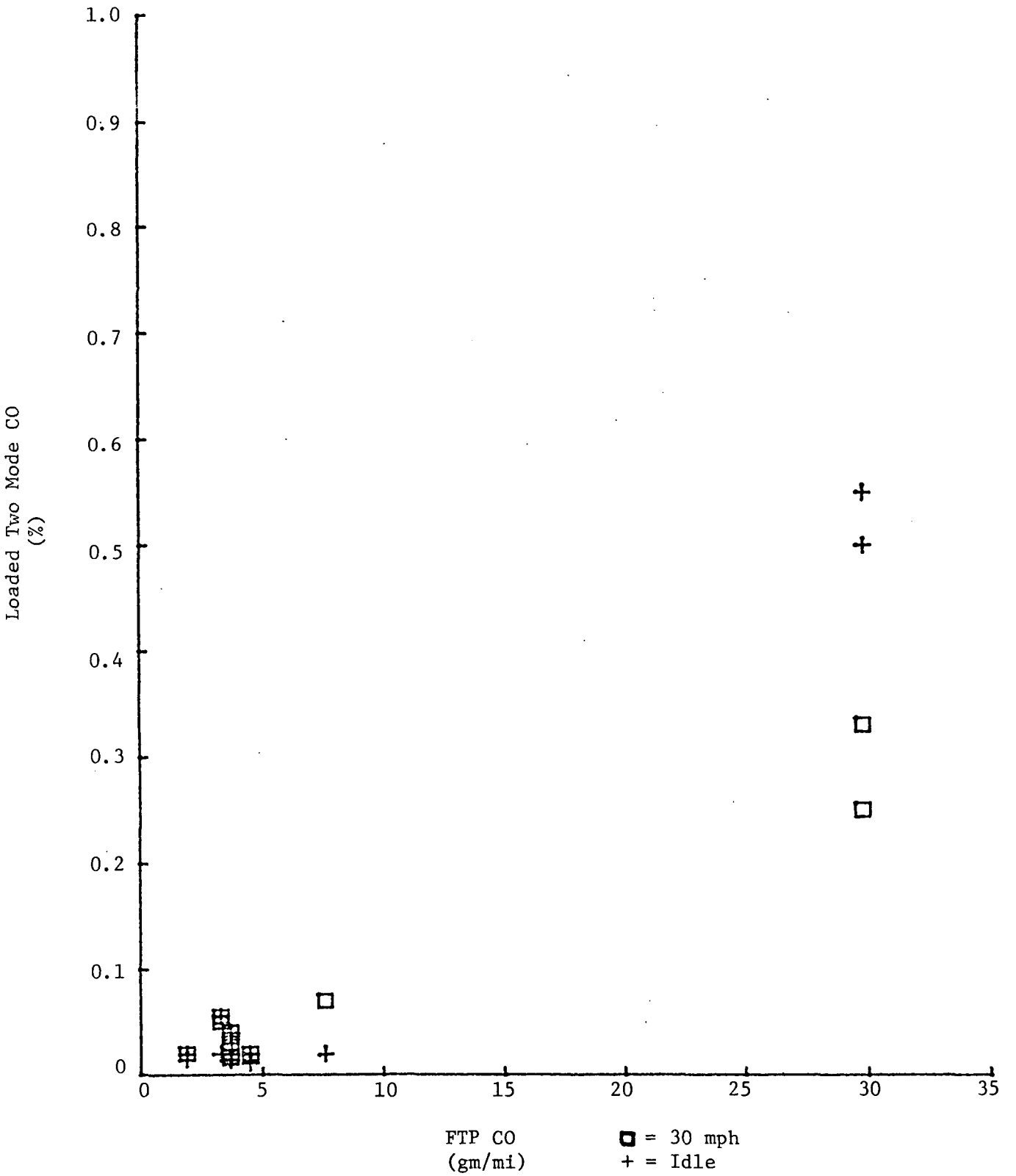


Figure 6

ASPEN

FTP HC vs. Loaded Two Mode HC

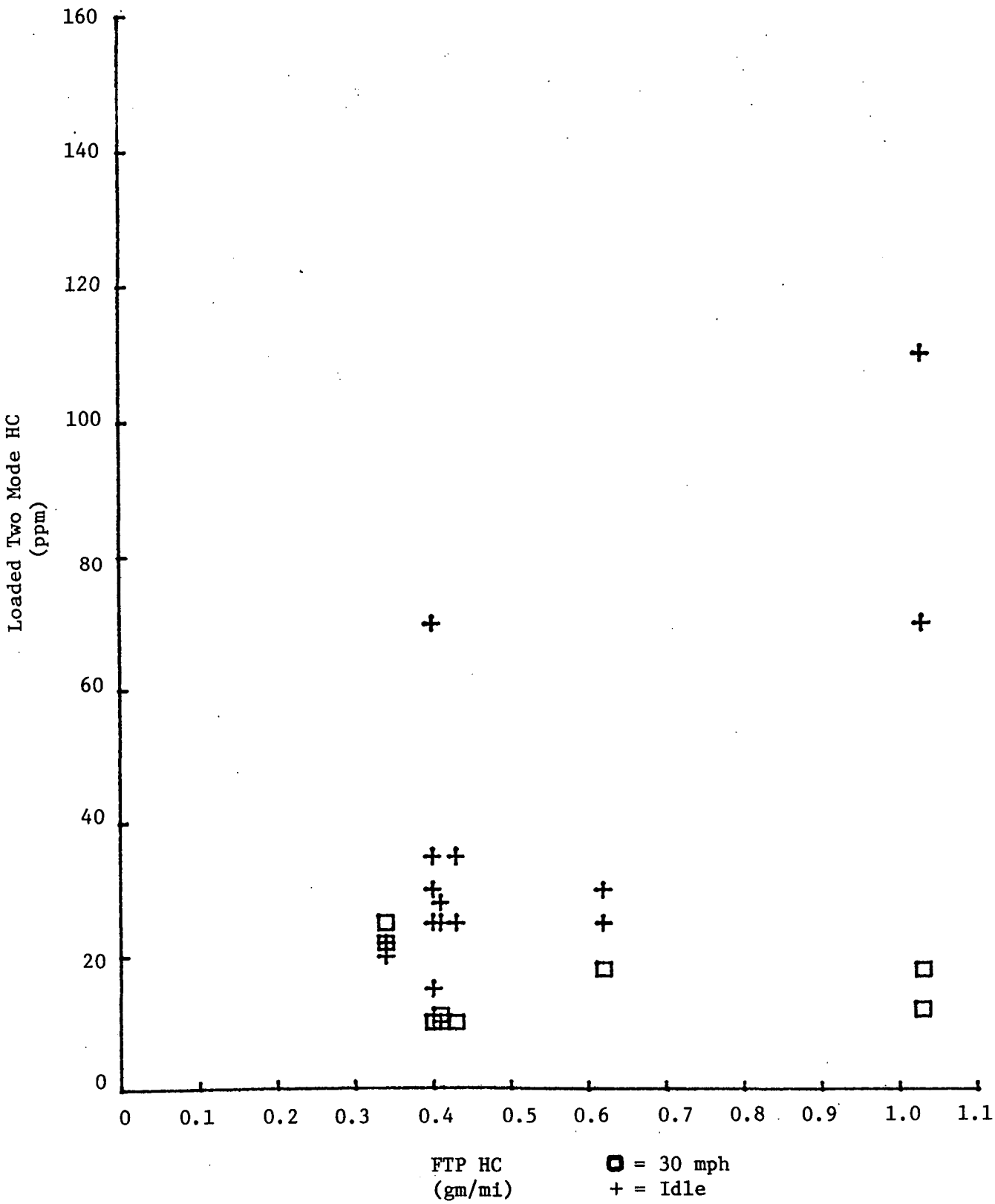


Figure 7

ASPEN

FTP CO vs. Two Speed Idle CO

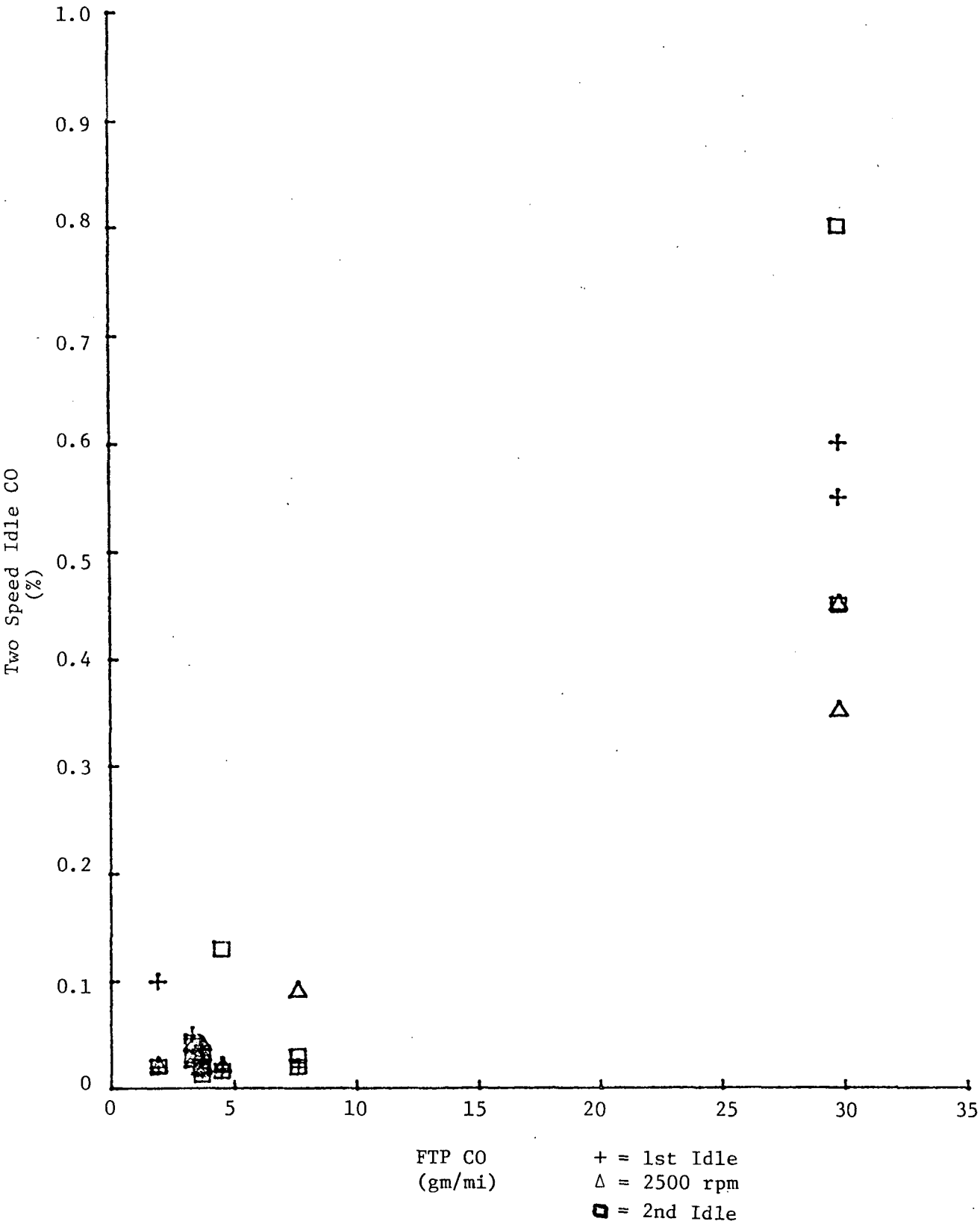
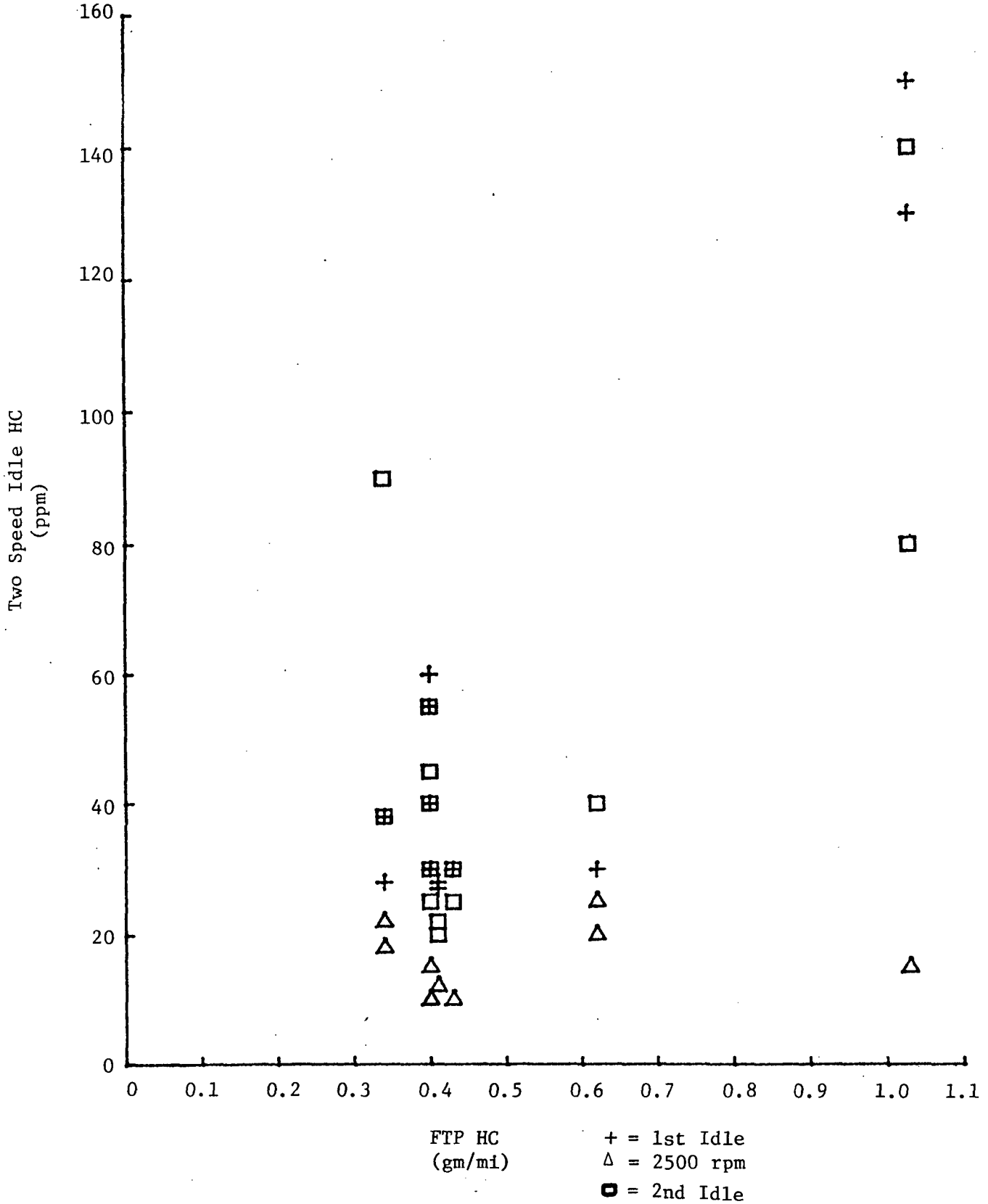


Figure 8

ASPEN

FTP HC vs. Two Speed Idle HC



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