Effect of Engine Speed on Undiluted HC and CO Emissions

by

Gordon J. Kennedy

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Characterization and Applications Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Office of Air and Waste Management
U.S. Environmental Protection Agency

Abstract

Increased interest in motor vehicle emission inspection/maintenance programs and specifically on the warranty provisions of section 207(b) of the Clean Air Act has focused attention on the short exhaust emission tests. Lack of concurrence on the approach to specifying engine speed requirements during these short tests has prompted this study in which a small number of vehicles were tested at MVEL to determine the levels of undiluted HC and CO emissions at different engine speeds. This study was conducted to discover what pattern, if any, exists which might relate HC and CO exhaust emission levels to the vehicle engine's speed as this speed is changed under no-load conditions.

It was found in most cases, especially in the lower idle-speed ranges, that a small increase in engine speed results in a sharp drop in emission levels. It is apparent, therefore, that a "failed" vehicle could easily be caused to pass its idle test by merely increasing the idle speed sufficently to drop its emission levels below the established standards.

With emission levels dependent on engine speed, it behooves those involved with state inspection/maintenance programs to apply some degree of uniformity to engine idle settings prior to commencing idle emission tests. For the low-speed idle setting, the adjustment least likely to result in controversy would be to set the engine speed to the manufacturer's specification. For vehicles equipped with automatic transmissions, in which the idle speed is specified with the transmission in drive, the engine should be so adjusted prior to shifting the transmission to neutral for the emission tests. Since manufacturers' low-idle specifications are usually near minimum levels for smooth engine operation, tolerance limits for low-speed idle should be plus or mimus 100 RPM.

All idle emission tests should be performed in neutral (unloaded) to allow a uniform basis for vehicles equipped with either automatic or manual transmissions. It is mandatory that the high-speed idle tests be performed in neutral due to the increased stress and non-linear load which would otherwise occur with automatic transmissions. An unloaded high-idle speed of 2,500 RPM is being generally adopted by states as an optimum choice for inspection/maintenance high-speed undiluted emission tests. Due to the appreciable rate of emission changes with engine speed, exhibited by certain vehicles, even in the higher idle speed ranges, the tolerance limits should be no more than plus or minus 100 RPM.

I. Purpose

The purpose of this study is to determine whether relatively small changes in a vehicle's engine speed under no-load conditions can have a significant effect on its HC and CO emission levels. The results from this study will then be used to determine the advisability of first checking the engine idle speeds on all vehicles against some uniform set of specifications prior to performing the idle emission tests.

II. Introduction

With the advent of vehicle emission inspection/maintenance programs at the state level, considerable attention has been devoted to the simplest and least expensive emission test procedure--the undiluted idle test for HC and CO. Some states are stipulating a high-speed idle test in the range of 2,500 RPM in addition to the low-speed idle test. However, there seems to be a lack of concurrence regarding a uniform basis for setting the engine speed for the low-speed idle test, as well as a lack of guidance on what would constitute an optimum high-speed setting.

III. Discussion

Six pre-1975 vehicles and two 1976 vehicles, one of which was maladjusted prior to testing, were analyzed for undiluted HC and CO exhaust emission levels while being operated at various no-load engine speeds ranging from 500 RPM to 3,000 RPM. These tests were performed on February 22-25, 1977. Table 1 in the Appendix identifies the vehicles tested.

The Model EET-947 (Serial No. 248-08722) Analyzer, manufactured by Sun Electric Company was used to measure the undiluted HC and CO levels, as well as the engine speed for each test. This analyzer was calibrated on the first day of these tests by the MVEL Calibration and Maintenance Group. Ambient conditions were normal for this time of year in the laboratory.

Each vehicle was allowed to warm-up to normal operating temperature prior to testing. During testing, for each speed setting, the engine was allowed to operate at that particular speed sufficiently long to obtain stabilized readings for HC and CO.

Subsequent to these emission tests, those test vehicles equipped with automatic transmissions were again normalized to standard operating temperatures. The idle speed of each vehicle was then adjusted to the manufacturer's specifications with the transmission in drive. The transmission was then shifted to neutral, and the increased idle speed recorded in each case. A portable tachometer was used for these speed checks (Universal Tach Dwell Meter, manufactured by Mac Allied Tools Corp., serial number 001513).

IV. Results

Tables 2 through 9 list the HC and CO values which correspond to the various engine speed settings for Vehicles A through H, respectively. Table 10 lists the manufacturer's idle-speed specification to which the engine idle speed of each vehicle equipped with an automatic transmission was subsequently set, as well as the speed to which the engine increased when the transmission was shifted to neutral.

Figures 1 and 2 are plots of HC and CO emissions, respectively, versus engine speeds, taken from data listed in Tables 2 through 9.

V. Conclusions

From the plots in Figures 1 and 2, it is obvious that idle HC and CO emission levels vary considerably as engine speeds change. It can be seen that, in most cases, especially for HC from a vehicle being emission tested at an idle speed below 1,000 RPM, a "failed" vehicle could easily be caused to pass merely by increasing its idle speed. In some cases, either an increase or a decrease in engine speed could result in the vehicle passing. Vehicle A, for example, might fail to meet a CO standard at 600 RPM, but it might pass at either 550 or 650 RPM. Conversely, Vehicle A might pass a CO standard at 700 RPM, and fail at either 650 or 750 RPM.

Table 10 shows the disparity between idle engine speeds as measured in drive versus their increased values when those vehicles, equipped with automatic transmissions, are shifted to neutral. These changes in idle speeds, for this reason alone, could easily mark the difference between passage and failure on individual vehicles.

VI. Recommendations

For a vehicle requiring idle undiluted HC and CO exhaust emission measurements, it is recommended that the vehicle's engine idle speed be first checked to determine whether it meets its manufacturer's specification, by performing the following steps:

1. Allow the vehicle to be normalized to its standard operating temperature.

2. Perform any diagnostic checks or maintenance items which may be required prior to testing (depending upon requirements in the test program involved).

3. Check the engine low-speed idle setting against the vehicle manufacturer's specification. For a vehicle equipped with automatic transmission, make sure the speed is checked in drive or neutral, per the manufacturer's specification.

4. If the engine low-speed idle setting conforms to the manufacturer's specification; within tolerance limits of plus or minus 100 RPM; proceed with the exhaust emission tests. If the idle setting does not conform, arrange with the owner to have the idle setting corrected before proceeding with the emission tests.

5. For the high-speed idle emission test, increase the idle speed adjustment gradually to 2,500 RPM (within tolerance limits of plus or minus 100 RPM), and allow engine to stabilize at this speed before proceeding with taking emission measurements.

6. At the completion of emission tests, decrease the idle speed adjustment gradually to the manufacturer's low-speed idle specification before returning the vehicle to its owner.

APPENDIX

Table 1

Test Vehicles

Veh.	Description	VIN	CID	Trans.	Carb. Bbls.
A	76 Chev. Impala	1L69V6J139469	350	A	2
B	70 Plymouth Valiant	VL41COB215566	225	A	1
C	73 Ford Capri	GAECNP52810	122	M	2
D	71 Chev. Vega	141151U195333	140	M	1
E	71 Ford LTD	1J72N125679	429	A	4
F	70 Chev. Impala	164690U193074	350	A	2
G	70 Ford Falcon	OH27L159045	250	A	1
H	76 Ford LTD	6B74S228258	400	A	2

Vehicle A

Table 2

76 Chevrolet Impala, 1L69V6J139469,
350 CID, Auto., 2 Bbl Carb.*

RPM	HC (ppm)	CO (%)
500	360	3.9
600	365	4.7
700	350	3.3
800	350	4.1
900	310	4.0
1000	270	3.9
1500	155	2.9
2000	130	2.2
2200	100	1.2
2400	60	0.15
2600	40	0.05
2800	30	0.04
3000	25	0.03

* Carburetor maladjusted: Fuel-air mixture screws turned counterclockwise outward 4 3/4 turns from manufacturer's specification for richer mixtures.

Table 3

70 Plymouth Valiant, VL41COB215566,
225 CID, Auto., 1 Bbl Carb.

RPM	HC (ppm)	CO (%)
500	470	7.3
600	370	6.2
700	360	5.7
800	280	5.3
900	280	4.9
1000	325	4.3
1500	315	2.8
2000	125	0.25
2200	110	0.25
2400	105	0.35
2600	110	0.45
2800	105	0.60
3000	100	0.65

Table 4

73 Ford Capri, GAECNP52810,
122 CID, Manual, 2 Bbl. Carb.

RPM	HC (ppm)	CO (%)
550	300	3.4
600	310	4.1
700	290	5.1
800	250	4.6
900	200	3.2
1000	150	2.3
1500	90	1.2
2000	80	1.1
2200	50	0.5
2400	45	0.4
2600	40	0.3
2800	30	0.2
3000	30	0.15

Table 5

71 Chevrolet Vega, 141151U195333,
140 CID, Manual, 1 Bbl. Carb.

RPM	HC (ppm)	CO (%)
550	500	0.5
600	510	1.0
700	400	0.2
800	130	0.15
900	80	0.15
1000	70	0.13
1500	45	0.10
2000	40	0.12
2200	40	0.12
2400	40	0.22
2600	40	0.26
2800	45	0.45
3000	50	0.55

Table 6

71 Ford LTD, 1J72N125679,
429 CID, Auto., 4 Bbl. Carb.

RPM	HC (ppm)	CO (%)
500	550	3.9
600	280	0.9
700	205	0.95
800	160	0.2
900	130	0.18
1000	90	0.18
1500	80	0.18
2000	80	0.25
2200	100	0.35
2400	110	0.50
2600	110	0.60
2800	120	0.75
3000	115	0.95

Table 7

70 Chevrolet Impala, 164690U193074,
350 CID, Auto., 2 Bbl. Carb.

RPM	HC (ppm)	CO (%)
500	450	1.3
600	180	1.2
700	160	1.3
800	150	1.3
900	140	1.8
1000	120	1.7
1500	95	1.5
2000	65	1.55
2200	55	1.8
2400	85	2.4
2600	85	2.3
2800	80	1.7
3000	60	1.2

Table 8

70 Ford Falcon, OH27L159045,
250 CID, Auto., 1 Bbl. Carb.

RPM	HC (ppm)	CO (%)
500	900	4.3
600	790	4.2
700	710	4.1
800	510	3.5
900	420	2.9
1000	360	2.2
1500	130	0.2
2000	125	0.4
2200	140	0.65
2400	160	1.35
2600	150	1.5
2800	155	1.55
3000	165	1.7

Table 9

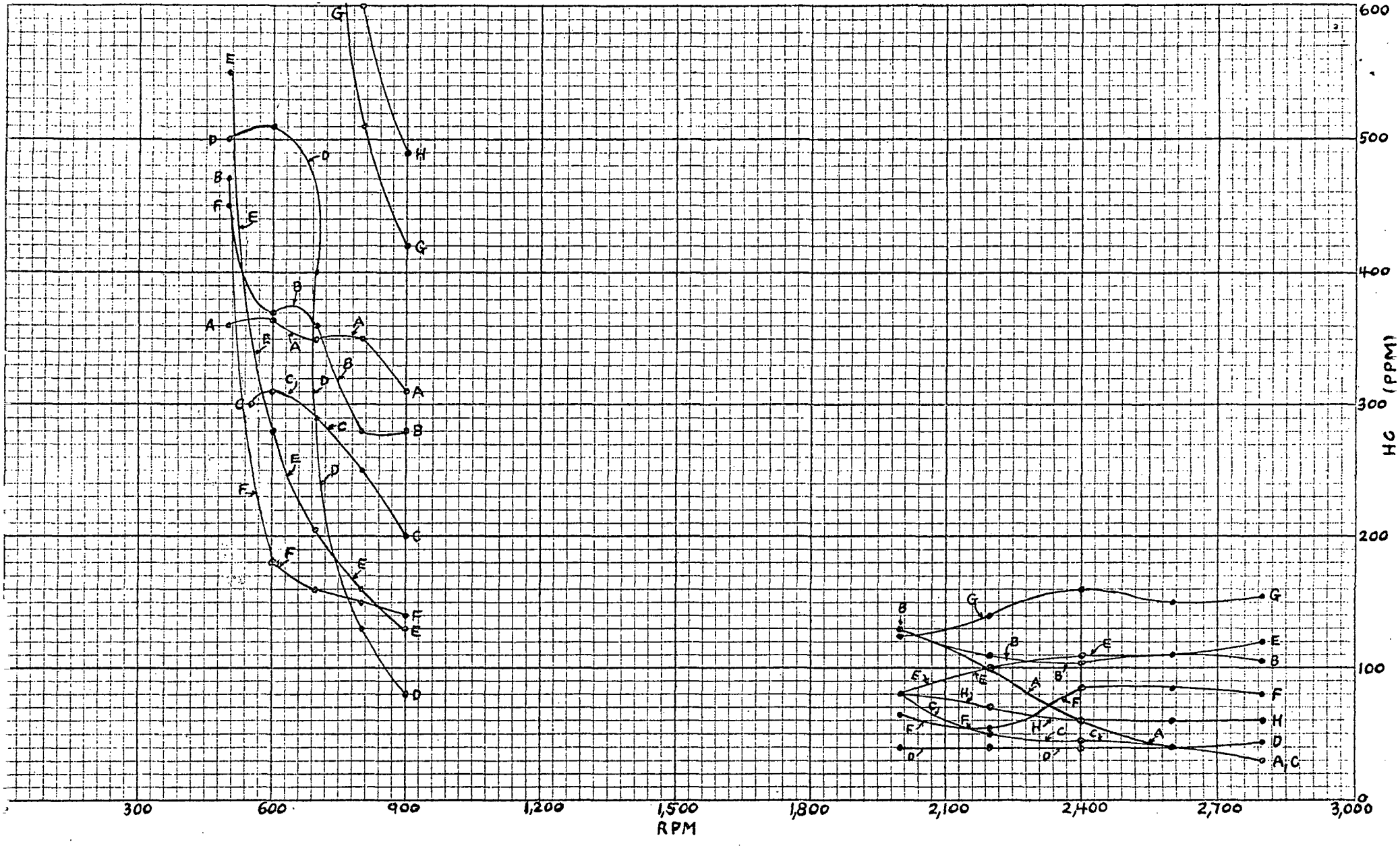
76 Ford LTD, 6B74S228258,
400 CID, Auto., 2 Bbl. Carb.

RPM	HC (ppm)	CO (%)
500	2000	6.8
600	1300	7.4
700	810	6.6
800	600	5.7
900	490	4.8
1000	450	3.9
1100	440	3.3
1200	450	2.6
1300	440	1.9
1400	360	1.3
1500	220	1.2
2000	80	0.1
2200	70	0.06
2400	60	0.05
2600	60	0.03
2800	60	0.03
3000	60	0.03

Table 10

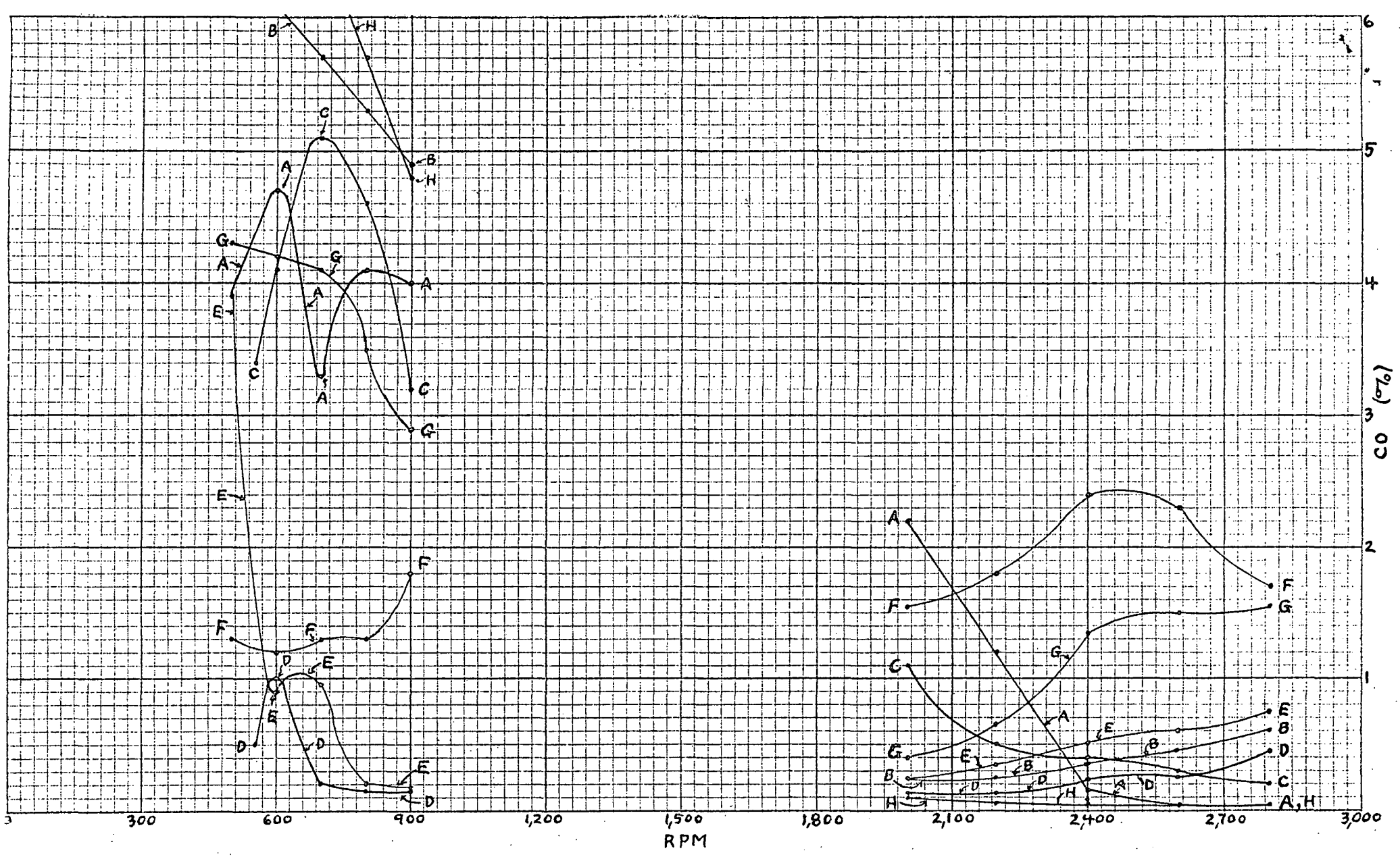
Veh.	Mfr's. Idle Speed Specs. (RPM) (Veh. with Auto, Trans, in Drive)	Idle Speed When Shifted to Neutral
A	600 D	800 N
B	650 D	840 N
E	600 D	740 N
F	600 D	760 N
G	500 D	580 N
H	600 D	760 N

NOTE: The manufacturer's idle speed specification for Vehicle C is 750 RPM, and for Vehicle D 850 RPM, both of which are measured with transmission in neutral.



UNDILUTED HC VS. ENGINE SPEED

FIGURE 1



UNDILUTED CO VS. ENGINE SPEED

FIGURE 2