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Effects of Gasohol on Idle HC and CO Emissions

by

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Office of Air, Noise, and Radiation
U.S. Environmental Protection Agency

Summary

A test program was run to investigate the effects of gasohol on CO and HC emissions on an I/M idle test. Three vehicles were set-up to operate on either gasoline or gasohol. A Hamilton emissions analyzer was used to measure tailpipe emissions. CO emissions were varied in each of the cars by adjusting the idle mixture screw, and HC emissions were varied by inducing a misfire with a misfire generator.[1] At each CO and HC value as specified in the program, the fuel was switched from gasoline to gasohol while its effect was noted on tailpipe emissions. The data obtained provided a basis for determining gasohol's ability to reduce CO and HC emissions for an idle test.

As the cars were maladjusted, gasohol was found to reduce idle CO about 1.1% CO. The reduction in idle CO was relatively constant for all three cars between idle mixture settings of 1.5% and 7.0% CO, and the catalyst cars experienced a greater average reduction (Figures 3-5).

Unlike the relatively constant idle CO reductions, idle HC reductions attributed to gasohol were vehicle dependent. A non-catalyst car experienced practically no reductions, a catalyst car experienced an average 188 ppm reduction, and a second catalyst car experienced a complete reduction (to zero) for all levels of HC tested[2] (Figures 6-8).

This limited data indicate that a catalyst vehicle just passing New Jersey standards of 3.0% CO and 300 ppm HC on gasohol would emit about 4.1% CO and 480 ppm HC on gasoline. Similarly, a catalyst vehicle just passing Portland standards of 1.0% CO and 225 ppm HC would emit about 2.1% CO and 400 ppm HC on gasoline.

Background

A previous EPA test program[3] using a test procedure similar to the standard FTP test on a fleet of eleven passenger cars has shown that gasohol[4] reduces exhaust HC mass (gm/mile) emissions by about nine percent and reduces exhaust CO mass (gm/mile) emissions twenty to thirty-four percent compared to gasoline. However, evaporative HC emissions, which are not measured in an idle test, increased 62%, resulting in a net HC increase on vehicles fueled with gasohol. The extensive use of idle tests in State I/M programs warranted determining gasohol emission characteristics on an idle test procedure.

1/ A misfire generator works by grounding the primary of the ignition coil a controllable percentage of time.

2/ Levels of HC were induced by misfire to the limit of HC observed with this car on gasoline (305 ppm HC).

3/ "Gasohol Test Program," Richard Lawrence, TAEB, MVEL, EPA, December, 1978.

4/ 10% ethanol, 90% Gasoline.

Purpose

The purpose of this study was to investigate the effects of gasohol on CO and HC emissions in an I/M idle test.

Test Program

Three vehicles were set up to operate from two fuel containers at the front of the vehicles. The vehicles used were a 1974 Ford Maverick (no catalyst), a 1977 Chevette (pellet catalyst), and a 1979 Ford Fairmont (monolith catalyst). Vehicle specifications are tabulated in Figure 1. A selector valve was set up to switch operation of the vehicles between two fuels. Fuels used were Indolene HO (Fuel 1) and 90% Indolene + 10% Ethanol (Fuel 2). Indolene HO is a standard reference test fuel. The change in emissions caused by the addition of ethanol to Indolene is similar to the change in emissions caused by the addition of ethanol to commercial fuel.[5]

The following procedure was used to test each vehicle in each configuration:

1. Warm-up car at idle 15 minutes on Fuel 1.
2. Disconnect and plug cannister line to carburetor.[6]
3. Operate at 2500 rpm for 1 minute.
4. Drop back to idle and read HC, CO and rpm.
5. Operate at 2500 rpm for 1 minute, read HC, CO.
6. Switch to Fuel 2 and purge (at 2500 rpm).
7. Drop back to idle and read HC, CO and rpm.
8. Operate at 2500 rpm 1 minute, read HC, CO.
9. Switch back to Fuel 1 and purge (at 2500 rpm).
10. Drop back to idle and read HC, CO and rpm.
11. Change initial HC or CO as indicated in the following configurations.

5/ "Gasohol Test Program", Richard Lawrence

6/ Cannister line was disconnected to reduce test-to-test variability caused by cannister loading and purging.

Target Configurations

1. Adjustment of idle mixture screw to vary CO.

   a. Fairmont and Chevette: As-Received, .3%, .5%, 1.0%, 2.0%, 3.0%, 4.0%, 5.0% CO.

   b. Maverick: As-Received, .3%, .5%, 1.0%, 2.0%, . . . , 8.0% CO.

2. Inducement of misfire to vary HC.

   a. Fairmont and Chevette: As-Received, 100 ppm or less, 200, 300, 400, 500, 600 ppm Hexane.

   b. Maverick: As-Received, 100 ppm or less, 200, 300, . . ., 900 ppm Hexane.

3. Adjustment of idle mixture plus misfire to vary both CO and HC.

   a. Fairmont and Chevette:

CO	2%	3%	3.5%	4%	5%	6%
HC	200	300	350	400	500	600

   b. Maverick:

CO	2%	3%	4%	5%	6%
HC	200	300	400	500	600

Results and Discussion

Before testing, both Hamilton analyzers were calibrated according to manufacturer procedures with gas standards available at MVEL. Calibration results are explained in Figure 2.

During testing, it was found that numerous "flow faults"[7] occurring in the gas sample line of the analyzer were caused by excessive water build-up in the gas sample line. A water trap was added to the sample line to prevent this condition from occurring. Sample line modification is illustrated in Figure 2.

Also during testing it was found that one of the test cars (1979 Fairmont) had a return line from the fuel pump to the gas tank. When remote tanks were connected to the fuel pump, unused fuel from these tanks was drained into the vehicle's main tank. This situation was remedied by returning unused fuel to the inlet side of the fuel pump.

The following list of comparisons explains results obtained from testing. Data is graphed and tabulated in the Appendix.

7/ A "flow fault" condition is observed on the analyzer in the form of an indicator light whenever flow is restricted in the sample line.

When Idle Mixture Screw was Adjusted:

1. Idle CO decreased on gasohol compared to gasoline by an average of 1.14% CO between idle settings of 1.2% CO and 8.4% CO. A clear illustration of this decrease is shown for each car in Figures 9-11. The two catalyst cars experienced a greater average reduction of CO (1.28% CO) than the non-catalyst car (.90% CO).

2. At 2500 rpm:

   a. In the non-catalyst car CO emissions were less on gasohol than gasoline by 1.45% CO.

   b. In the catalyst cars, CO emissions were nearly zero for all configurations (both gasoline and gasohol).

When Misfire was Induced with a Misfire Generator:

3. Idle HC decreased on gasohol compared to gasoline by an average of:

   a. 31 ppm Hexane for the non-catalyst car over a range of 100-700 ppm.

   b. 188 ppm for the pelleted catalyst car over a range of 300-700 ppm, and

   c. 100% reduction for four configurations tested on the monolithic catalyst car (70-305 ppm).

These results are illustrated graphically in Figures 12-14.

4. At 2500 rpm, average HC emission on gasohol:

   a. Decreased in the non-catalyst car 63 ppm from gasoline.

   b. Remained relatively stable at zero for both catalyst cars (both gasoline and gasohol).

When Idle Mixture Screw was Adjusted While Misfire was Induced:

5. Idle CO decreased on gasohol compared to gasoline by an average of .85% CO (three cars).

6. Idle HC was almost unchanged in the non-catalyst car, but decreased on gasohol compared to gasoline on the catalyst cars an average of 109 ppm.

These results are illustrated graphically in Figures 15-17.

Conclusions

Limited data gathered from this test program clearly demonstrates gasohol's ability to reduce CO and HC emissions at idle as compared to gasoline. Idle emissions decreased on gasohol compared to gasoline by about 1.1% CO and 200 ppm HC on two catalyst equipped vehicles when they were operated close to New Jersey I/M standards of 3.0% CO and 300 ppm HC.

Evaporative HC emissions and NOx exhaust emissions are not measured during the I/M idle test. However, data taken during the earlier Gasohol Test Program indicates that these emission components increase on gasohol.

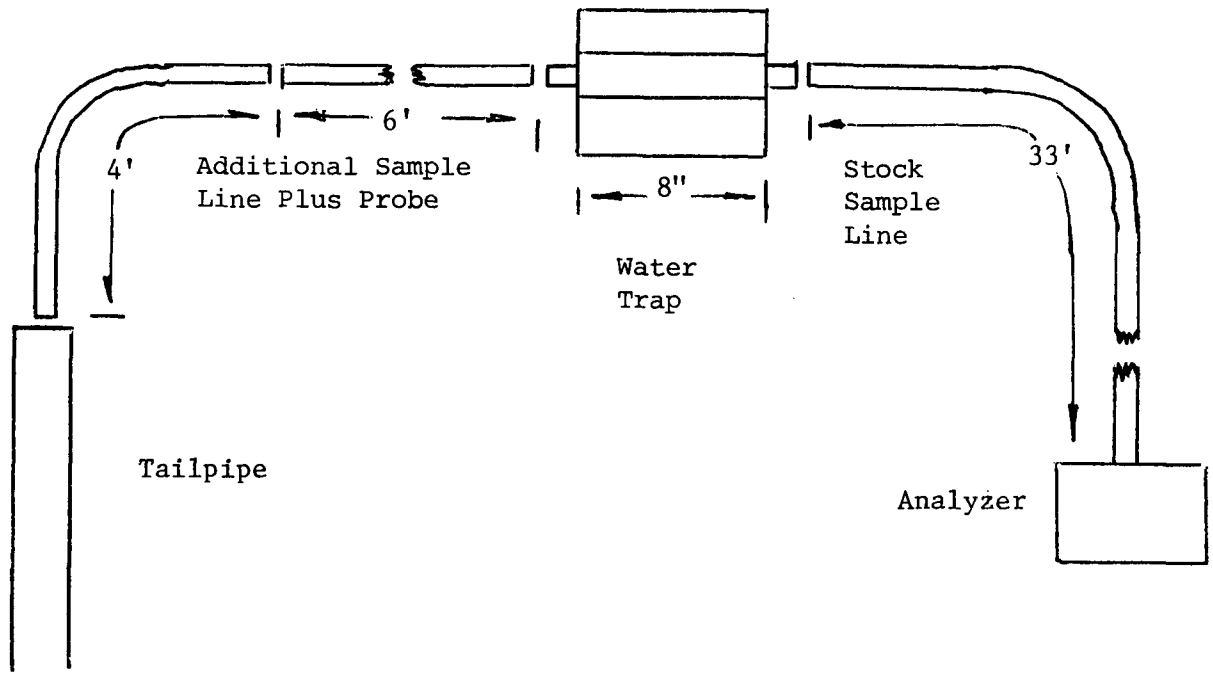
Appendix

Figure 1 Vehicle Specifications

	1974 Maverick	1977 Chevette	1979 Fairmont
Identification	G12-28104	EPA-128435	G51-11375
Mileage	60500	6600	1000
Year	1974	1977	1979
EGR	Yes	Yes	Yes
Air Pump	Yes	No	No
Catalyst	None	Pellet	Monolith
Eng. Configuration	6-inline	4-inline	4-inline
Displacement	250 CID	85 CID	140 CID

Fig. 2. Sample Line Modification: Hamilton Analyzers

Diagram shows addition of water trap to stock sample line.



Calibration of Analyzers

Hamilton Computerized Emissions Analyzers were used to measure tailpipe emissions during testing. The manufacturer states the analyzer can detect HC and CO in the following ranges and tolerances*:

Emission	Range	Tolerance
CO	0.0 - 10.0%	±3% of full scale
HC	0 - 2000 ppm (hex.)	±3% of full scale

The analyzer was calibrated before testing began according to manufacturer procedures using gas standards of HC and CO in the following concentrations:

Gas	Concentration
HC	3815.5 ppm propane
CO	5.158% CO

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* Autosense Owner's Manual, Hamilton Test Systems, Autosense Service Center, 900 River Street, Windsor, Connecticut 06095.

Figures 3-5. CO on Gasoline (% CO) vs. Change in CO (% CO) From Gasoline to Gasohol. All Changes are reductions.

Figure 3

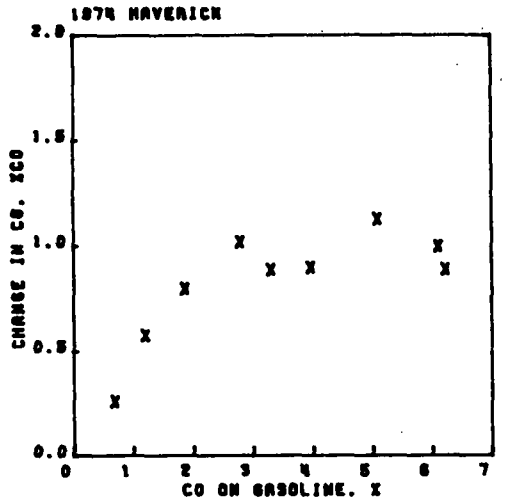


Figure 4

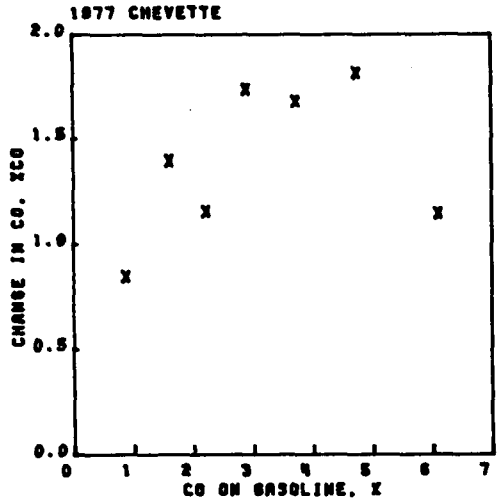
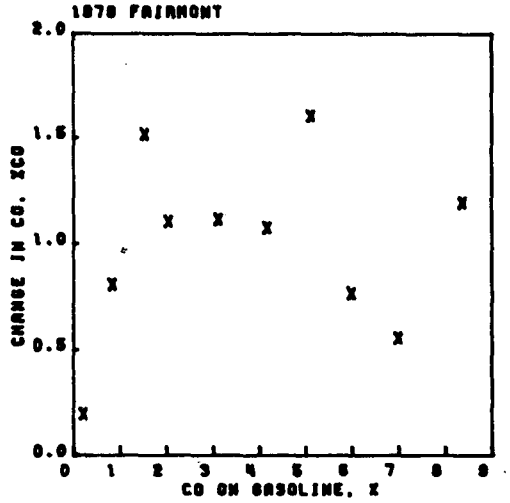


Figure 5



Figures 6-8. HC on Gasoline (ppm HC) vs. Changes in HC (ppm HC) From Gasoline to Gasohol. All Changes are reductions.

Figure 6

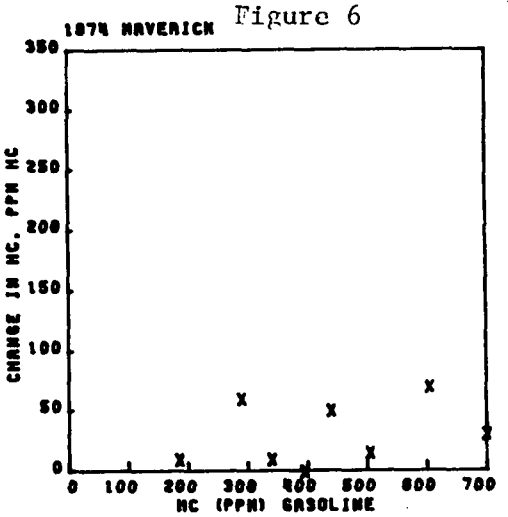


Figure 7

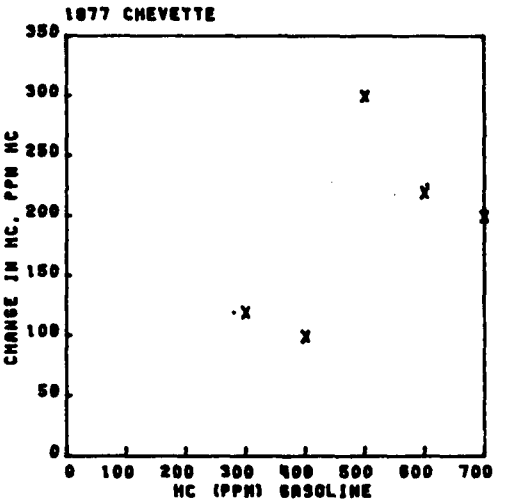
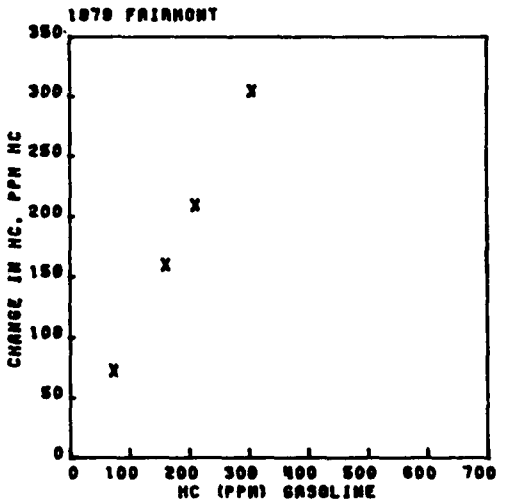


Figure 8



Figures 9-11. Idle CO: Gasoline vs. Gasohol (% CO)

Figure 9

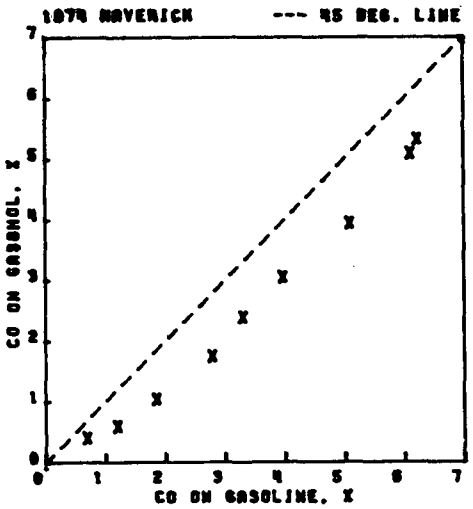


Figure 10

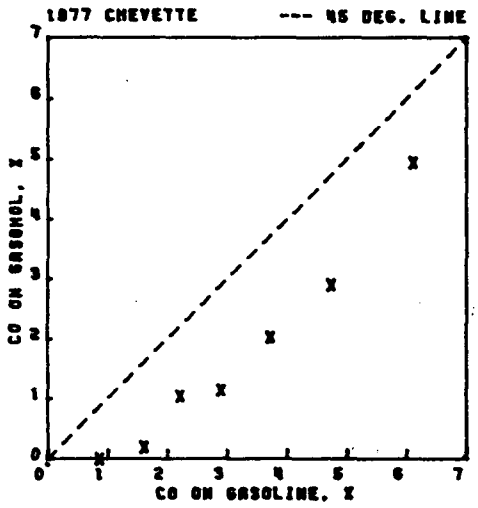
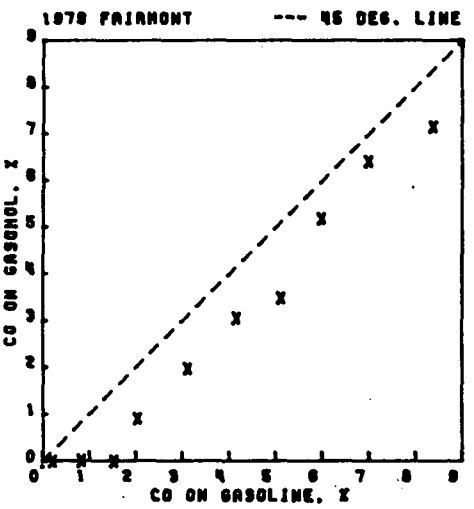


Figure 11



Figures 12-14. Idle HC: Gasoline vs. Gasohol (ppm HC)

Figure 12

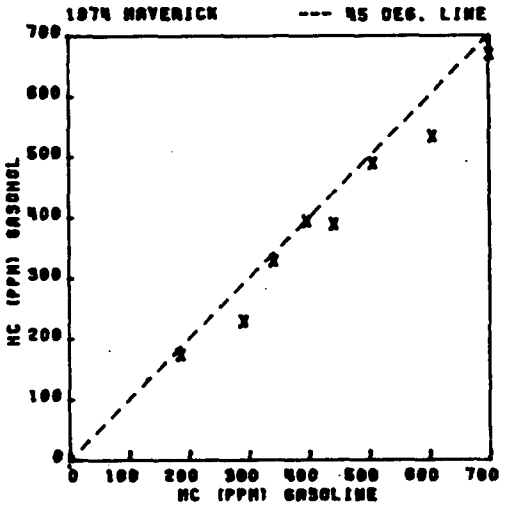


Figure 13

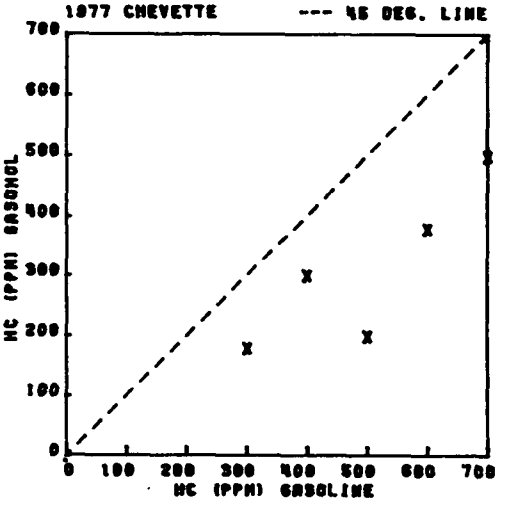


Figure 14

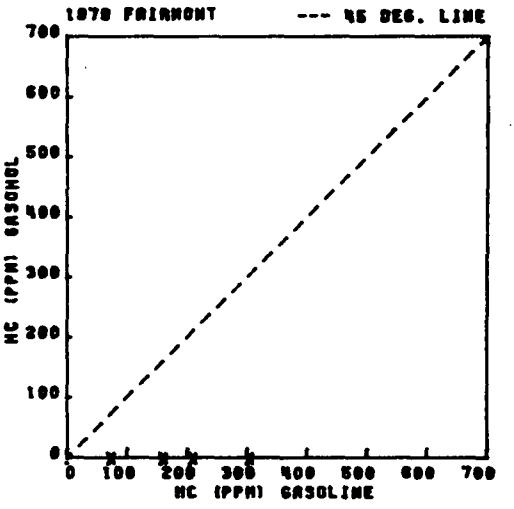


Table 2. 2500 rpm CO Gasoline vs. Gasohol, Maverick Only*

	% CO Gasoline	% CO Gasohol	Diff.	% Diff.
AR	3.96	2.30	1.66	42
	4.82	3.28	1.54	32
	4.40	2.99	1.41	32
	4.62	3.49	1.13	24
	4.10	3.00	1.10	27
	4.31	2.81	1.50	35
	4.24	3.27	.97	23
	4.92	1.78	3.14	64
	3.77	3.19	.58	15

Average of Differences (column 3)

1.45 (s = .36)

* Chevette and Fairmont exhibited no difference in 2500 rpm gasoline and gasohol readings (approximately zero % CO on both fuels).

Table 3. Idle HC Gasoline vs. Gasohol

	HC ppm Gasoline	HC ppm Gasohol	Diff.	% Diff.
		1974 Maverick		
*AR	185	175	10	5
	290	230	60	21
	340	330	10	3
	395	395	0	0
	440	390	50	11
	505	490	15	3
	605	535	70	12
	700	670	30	4
		1977 Chevette		
AR	300	180	120	40
	400	300	100	25
	500	200	300	60
	600	380	220	37
	700	500	200	29
		1979 Fairmont**		
	73	0	73	100
	160	0	160	100
	210	0	210	100
	305	0	305	100

Average of Differences (column 3)

Maverick 31 (s = 26)
Chevette 188 (s = 81)
Fairmont: All reductions were 100% reduction.

* "AR" is as-received condition.
** 305 ppm HC on gasoline was HC reading at 10.0% misfire.

Figures 15-17. Idle CO vs. HC: G asoline to Gasohol

Idle CO was adjusted with idle mixture screw while HC was adjusted with misfire generator.

Figure 15

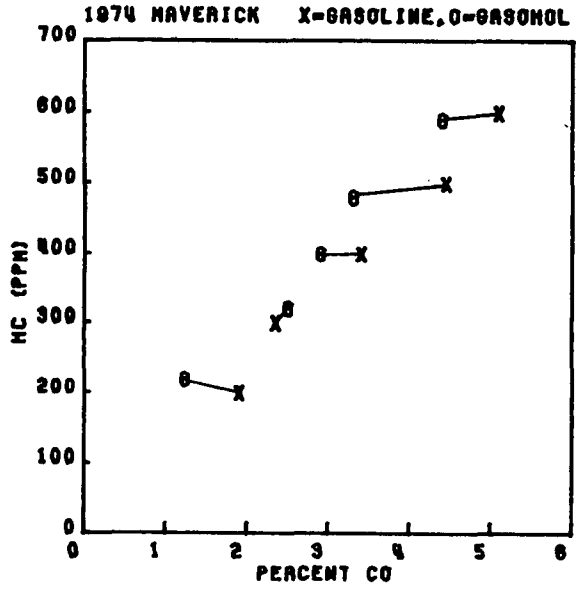


Figure 17

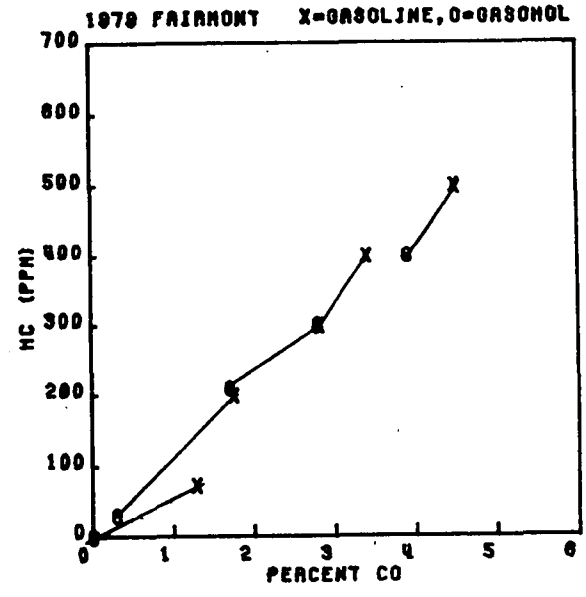


Figure 16

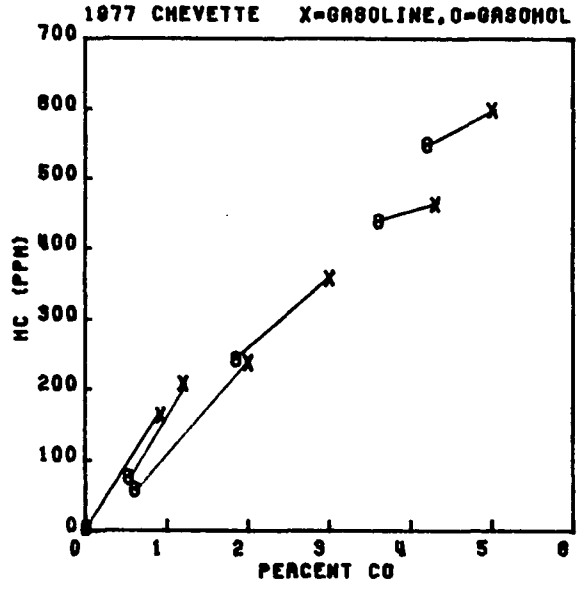


Table 1. Idle CO: Gasoline vs. Gasohol

	% CO Gasoline	% CO Gasohol	Diff.	% Diff.
		1974 Maverick		
*AR	.68	.42	.26	38
	1.19	.61	.58	49
	1.85	1.05	.80	43
	2.78	1.76	1.02	37
	3.29	2.40	.89	27
	3.96	3.06	.90	28
	5.08	3.95	1.13	22
	6.10	5.10	1.00	16
	6.22	5.33	.89	14
		1977 Chevette		
AR	.86	.01	.85	98
	1.60	.20	1.40	87
	2.21	1.05	1.16	52
	2.89	1.15	1.74	60
	3.72	2.04	1.68	45
	4.73	2.91	1.82	39
	6.10	4.95	1.15	19
		1979 Fairmont		
AR	.21	.01	.20	95
	.83	.02	.81	98
	1.53	.01	1.52	99
	2.03	.92	1.11	55
	3.10	1.98	1.12	36
	4.15	3.07	1.08	26
	5.10	3.49	1.61	31
	5.97	5.20	.77	13
	6.98	6.42	.56	8
	8.37	7.17	1.20	14

Average of Differences (column 3)

Maverick	.90 (s = .16)	Excluding leanest point.**
Chevette	1.40 (s = .36)	" " "
Chevette and Fairmont	1.28 (s = .30)	Excluding leanest points.
Fairmont	1.13 (s = .35)	Excluding leanest two points.
Total	1.14 (s = .36)	Excluding leanest points.

* "AR" is As-received condition.

** Leanest points were excluded because average reduction is greater than CO gasoline initial setting.

Table 4. 2500 rpm HC Gasoline vs. Gasohol

Maverick Only*

HC ppm Gasoline	HC ppm Gasohol	Diff.	% Diff.
205	190	15	7
305	265	40	13
340	325	15	4
445	370	75	17
450	360	90	20
575	505	70	12
665	590	75	11
800	680	120	15

Average of Differences (column 3)

63 (s = 37)

* Chevette and Fairmont exhibited very low (less than 20 ppm) HC levels at 2500 rpm for both gasoline and gasohol.

Table 5 - Idle CO and HC: Gasoline vs. Gasohol
Combined idle mixture adjustment and misfire induced

% CO Gasoline	% CO Gasohol	% CO* Diff.	% Diff	HC ppm Gasoline	HC ppm Gasohol	ppm Diff.	% Diff
				1974 Maverick			
1.90	1.23	.67	35	200	220	20+	10+
2.35	2.50	.15	6	300	320	20+	7+
3.40	2.90	.5	15	400	400	0	0
4.45	3.30	1.15	26	500	480	20	4
5.10	4.40	.7	14	600	590	10	2
				1977 Chevette			
.92	.01	.91	99	165	6	159	96
1.2	.52	.68	57	210	78	132	63
2.0	.60	1.4	70	240	60	180	75
3.0	1.85	1.15	38	360	245	115	32
4.3	3.60	.70	16	465	440	25	5
5.0	4.20	.80	17	600	550	50	8
				1979 Fairmont			
1.29	.01	1.28	100	73	0	73	100
1.75	.30	1.45	83	200	30	170	85
2.82	1.70	1.12	40	300	210	90	30
3.40	2.80	.60	18	400	300	100	29
4.50	3.90	.60	13	500	400	100	20

Average of Differences	% CO Diff	ppm Diff.
Maverick	.57 (s = .47)	2 (s = 18)
Chevette	.94 (s = .28)	110 (s = 61)
Fairmont	1.01 (s = .39)	107 (s = 39)
Catalyst Cars (Chevette & Fairmont)	.97 (s = .32)	109 (s = 49)

"+" sign means increase in emissions

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