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Analysis of Propane Gain Used as a Screen on the Portland Element III Sample

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Propane gain values have been collected from 292 Portland Element III (1975-77 model year) vehicles along with as-received FTP and idle test emission measurements. This data is used here to compare the expected failure rate, errors of commission, and the amount of FTP excess emissions identified if one of two sets of idle values or one of four propane gain values had been used as a cutpoint to screen the vehicles in the sample with high emissions. Table 1 contains the results when all 292 vehicles are combined into a single group and the cutpoints applied. Table 2 applies the cutpoints to only those 127 vehicles (43.5%) which are equipped with air injection systems and Table 3 applies the cutpoints to the remaining 165 vehicles (56.5%), which are without air injection systems.

The Portland Element III sample was chosen to represent a wide range of emission control technology types existing in the Portland vehicle population. This means that in some cases low selling vehicles with a unique emission control technology type may be somewhat over-represented in the Element III sample. A complex weighting scheme allows this sample to be used to represent a Portland or National vehicle mix when desired. The values calculated in this analysis, however, have not been weighted to represent any known vehicle mix. The uncertainty introduced by not weighting the vehicle sample is not expected to change the observed trends or conclusions reached in this analysis.

The idle cutpoints referred to in this analysis as "Houston" idle cutpoints are the proposed cutpoint values to be used in the Houston pilot I/M program. The "Portland" idle cutpoints are the most typical cutpoint values used in the current Portland, Oregon Department of Environmental Quality (DEQ) I/M program. Neither of these sets of idle cutpoints represent suggestions by EPA, but only represent points for discussion of the relative merits of idle and propane test procedures.

Vehicles whose measured idle exhaust emissions are greater than either the idle hydrocarbon (HC) or idle carbon monoxide (CO) cutpoint or both fail the idle test. Vehicles whose measured propane gain values in neutral are less than the propane gain cutpoint fail the propane test.

Errors of commission are traditionally defined as those vehicles which pass their FTP test standards, both for hydrocarbons (HC) and carbon monoxide (CO), but which are failed by a particular I/M short test. For example, in Table 1, 5.1% (15 vehicles) of the sample had measured HC emissions of 1.5 gm/mi or less and CO emissions of 15 gm/mi or less, but had either a measured idle exhaust HC value more than 225 ppm or a measured idle exhaust CO value more than 1.0%. This value (5.1%) represents the errors of commission (as traditionally defined) in this sample using the "Portland" idle cutpoints. It is recorded in Table 1 under the Errors of Commission heading in the "FTP HC & CO" column. The "FTP HC" and the "FTP CO" columns under the Errors of Commission heading in Tables 1-3 represent a slightly different view of errors of commission. The rates in the "FTP HC" column represent those vehicles which pass the HC portion of the FTP test but fail a short

test. The rates in the "FTP CO" column represent those vehicles which pass the CO portion of the FTP test but fail a short test. Some of these vehicles which pass the FTP for one pollutant may have failed the FTP for the other pollutant and therefore would have failed the overall FTP standards. As a result, these rates will be higher than the rates of error of commission involving vehicles which pass both the HC and CO portions of the FTP test.

FTP excess emissions are the total gm/mi emissions from the sample fleet in excess of their FTP standards. The FTP excess emissions identified by a short test is the sum of the FTP excess emissions of vehicles which fail the short test. The percent of FTP excess emissions identified is one measure of its effectiveness as a screen to identify vehicles which need emission related repair and/or adjustment. The more accurately a short test selectively fails the dirtiest cars, the higher will be the percent excess emissions identified.

Using a single propane test cutpoint of 10 rpm on all vehicles based on this sample, the failure rate would be about 30% (Table 1). Using an idle test and the "Houston" idle cutpoints for all 1975-77 vehicles the failure rate would drop to about 22%, yet the excess emissions identified would increase and the errors of commission would reduce significantly. This shows that, when applied to all 1975-77 vehicles as a group, the "Houston" idle test might prove to be a more effective screen than the propane test. However, if we divide the sample into two groups, with and without air injection systems (Tables 2 and 3), it is clear that the problems with the propane test primarily lie in its inability to screen vehicles with high emissions which have air injection systems. Table 4 compares the average FTP results, FTP failure rates, and total excess FTP emissions of the vehicles in the sample to those vehicles in the sample with and without air injection systems.

The error of commission rates for the propane test are higher for vehicles with air pumps (Table 2) than for vehicles without air pumps (Table 3). In Table 3, if we compare the propane cutpoint of 20 rpm with the "Houston" idle cutpoints on vehicles without air pumps, we can see that the propane test as a screen for high emitters is in this case very comparable to the idle test. Both have low error of commission rates and have fairly equal failure rates (about 30%). Even the FTP excess emissions identified are fairly close. The "Houston" idle test appears to have a tendency to identify vehicles with excess HC emissions, while the propane test, which only checks carburetor adjustment, appears to have a tendency to screen more vehicles with excess CO emissions than excess HC emissions.

Vehicles with air injection systems (Table 2) present problems for both the idle test and the propane test. For example, the data indicate that, in order to identify 40 percent of the excess HC emissions from cars with air pumps using the propane test, over 40% of then would have to be failed, using a propane gain cutpoint of 30 rpm. (Passing and failing cars at the random would on average identify the same percent excess emissions at the same failure rate). The error of commission rate (18.1%) at that propane gain cutpoint is quite high. The error of commission rate (0.0%) for the

"Houston" idle cutpoints is small, however the percentage of excess HC emissions identified is also small. This indicates that the "Houston" idle cutpoints, while avoiding errors of commission much more successfully than the propane test, have failed to screen out as many of the air pump vehicles which exceed FTP standards no doubt in large part because of the lower failure rate (9.4%). More vehicles would need to be failed to allow a substantial reduction in emission from those vehicles. The "Portland" idle cutpoints fail more cars (35.4%) and are more effective for these vehicles in terms of excess emissions; the error of commission rate (5.5%) is higher for this idle test but still less than one half the error of commission rate for any of the propane tests.

A possible reason for the higher error of commission rates using the propane test on vehicles equipped with air injection systems could be the combined effect of air injection in catalyst-equipped vehicles and the typical carburetor adjustment specifications of these vehicles. Air injection causes the catalyst to work more efficiently. The manufacturers who install air pumps can often readjust their carburetor specifications richer to improve driver-perceived performance and still pass FTP standards. These richer carburetor specifications result in small or zero propane gain values. Therefore vehicles with air pumps are over-represented in the group of vehicles which when adjusted to manufacturers specification have measured propane gain values which are below a given propane test cutpoint.

A propane I/M program testing vehicles with air injection systems might cause owners of many air injection vehicles to adjust their carburetors leaner than recommended by the manufacturer in order to pass the propane gain cutpoint. The leaner carburetor setting probably will result in some additional reduction in emissions from those cars and some fuel economy gains, possibly without causing any significant performance problems. If this is the case, no serious problems would arise. If serious problems (e.g., a group of vehicles is consistently unable to pass the propane cutpoint with acceptable driveability, leading to public dissatisfaction and adjust-readjust behavior), do arise because of propane testing of vehicles with air pumps, perhaps those vehicles could be exempted from propane testing altogether. Vehicles with air injection systems tend to have lower emissions than vehicles without air pumps (Table 4), even when maladjusted. It is estimated that vehicles with air pumps account for less than 20% of FTP excess emissions from all vehicles. The necessary reductions in overall automotive pollutants could be gained from other vehicles which, without air pumps, tend to have much higher emissions when maladjusted. Another approach to vehicles which have air injection systems might be some combination of propane testing, to determine the carburetor adjustment, and an idle test to gauge the overall vehicle's exhaust emissions.

The trends and values here were all based on the observations of the 292 Portland Element III vehicles. It should be noted that the Portland cars may be lower emitting than vehicles in areas without I/M programs and that consequently, the failure rates presented here may be lower than would occur in a non-I/M area. Nevertheless, these results are currently EPA's best estimate of how an actual propane test would fare when applied to a much larger sample of vehicles. New observations may surface in the existing or new data which may affect any conclusions presented here.

Table 1

Portland Element III
1975-77 Model Years
(292 Vehicles)

	Short Test	FTP Excess Emissions Identified		Errors of Commission (%)		
	Failures[3] (%)	HC(%)	CO(%)	FTP HC & CO[4]	FTP CO[5]	FTP HC[6]
Idle Cutpoint						
"Houston"[1]	21.6	65.0	62.2	0.0	0.0	1.4
"Portland"[2]	43.5	82.5	82.5	5.1	7.5	8.9
Propane Gain Cutpoint						
10	29.5	55.3	58.2	6.5	8.2	9.9
20	31.8	56.2	61.5	6.5	8.2	11.6
30	37.7	62.1	67.1	8.9	10.6	14.7
40	40.8	64.7	70.7	9.6	11.3	15.8

1: Idle CO cutpoint = 3.5%; Idle HC cutpoint = 400 ppm.
2: Idle CO cutpoint = 1.0%; Idle HC cutpoint = 225 ppm.
3: Idle exhaust measurement greater than either the Idle CO or Idle HC cutpoint fails the Idle Test; Propane Gain measurement less than the Propane Gain cutpoint fails the Propane Test.
4: Vehicles which pass both the FTP HC and CO standards but fail the short test.
5: Vehicles which pass the CO portion of the FTP but fail the short test.
6: Vehicles which pass the HC portion of the FTP but fail the short test.

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Table 2

Portland Element III
1975-77 Model Years With Air Pumps
(127 Vehicles)

	Short Test	FTP Excess Emissions Identified		Errors of Commission (%)		
	Failures[3] (%)	HC(%)	CO(%)	FTP HC & CO[4]	FTP CO[5]	FTP HC[6]
Idle Cutpoint						
"Houston"[1]	9.4	30.8	35.5	0.0	0.0	2.4
"Portland"[2]	35.4	74.0	78.4	5.5	9.4	10.2
Portland Gain Cutpoint						
10	33.9	30.1	42.7	15.0	18.9	22.0
20	36.2	32.3	46.0	15.0	18.9	23.6
30	41.7	41.5	49.4	18.1	22.0	26.8
40	44.9	48.2	54.9	18.9	22.8	27.6

1: Idle CO cutpoint = 3.5%; Idle HC cutpoint = 400 ppm.
2: Idle CO cutpoint = 1.0%; Idle HC cutpoint = 225 ppm.
3: Idle exhaust measurement greater than either the Idle CO or Idle HC cutpoint fails the Idle Test; Propane Gain measurement less than the Propane Gain cutpoint fails the Propane Test.
4: Vehicles which pass both the FTP HC and CO standards but fail the short test.
5: Vehicles which pass the CO portion of the FTP but fail the short test.
6: Vehicles which pass the HC portion of the FTP but fail the short test.

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Table 3

Portland Element III
1975-77 Model Years Without Air Pumps
(165 Vehicles)

	Short Test Failures[3] (%)	FTP Excess Emissions Identified HC(%)	FTP Excess Emissions Identified CO(%)	Errors of Commission (%) FTP HC & CO[4]	Errors of Commission (%) FTP CO[5]	Errors of Commission (%) FTP HC[6]
Idle Cutpoint						
"Houston"[1]	30.9	75.8	70.7	0.0	0.0	0.6
"Portland"[2]	49.7	89.1	85.6	4.8	6.1	7.9
Propane Gain Cutpoint						
10	26.1	62.3	63.0	0.0	0.0	0.6
20	28.5	63.7	66.4	0.0	0.0	2.4
30	34.5	68.7	72.6	1.8	1.8	5.5
40	37.6	69.8	75.8	2.4	2.4	6.7

1: Idle CO cutpoint = 3.5%; Idle HC cutpoint = 400 ppm.
2: Idle CO cutpoint = 1.0%; Idle HC cutpoint = 225 ppm.
3: Idle exhaust measurement greater than either the Idle CO or Idle HC cutpoint fails the Idle Test; Propane Gain measurement less than the Propane Gain cutpoint fails the Propane Test.
4: Vehicles which pass both the FTP HC and CO standards but fail the short test.
5: Vehicles which pass the CO portion of the FTP but fail the short test.
6: Vehicles which pass the HC portion of the FTP but fail the short test.

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Table 4

Portland Element III
1975-77 Model Years
(292 Vehicles)

	Percent of Sample	Average FTP (gm/mi)		FTP Failure Rate(%)			FTP Excess Emissions(%)*	
		HC	CO	HC or CO	HC	CO	HC	CO
With Air Pump	43.5	1.52	18.6	52.8	38.6	42.5	23.9	24.4
Without Air Pump	56.5	2.15	30.4	64.2	54.5	61.8	76.1	75.6
Total Sample	100.0	1.88	25.2	59.2	47.6	53.4	100.0	100.0

* Percent of all FTP excess emissions from the total sample

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