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MEMORANDUM

TO: Joe Somers, Phil Lorang USEPA

FROM: Rob Klausmeier, de la Torre Klausmeier Consulting
Sandeep Kishan, Radian International

DATE: February 19, 1998

SUBJECT: **DESCRIPTION OF THE HIGH AND LOW EMITTER PROFILE MODELS**

As an initial follow-up to our meeting on January 29, I am providing additional background on Radian's emission profiling models. Radian developed models to estimate probabilities that vehicles will be high emitters. These models are often referred to as high emitter profile (HEP) or low emitter profile (LEP) models. HEP models are typically used to target high emitters for testing; LEP models are typically used to exempt likely clean vehicles from I/M requirements. This latter case, exempting clean vehicles, is often termed "clean screen". LEP models have been proven to be able to screen out at least 50% of the vehicles from inspection requirements with little reduction in exhaust emission benefits. This section briefly describes the HEP and LEP models. Data are presented on the effectiveness of using it to screen-out clean vehicles from testing requirements.

BACKGROUND ON THE HIGH EMITTER PROFILE (HEP) AND LOW EMITTER PROFILE (LEP) MODELS

The high emitter profile model (HEP) was first developed for the California Bureau of Automotive Repair (BAR) for use in the California Smog Check Program. A fundamental theme of the California Smog Check Program is to target high emitters and require that they be inspected at closely scrutinized inspection facilities. Working closely with BAR, Radian developed several versions of the HEP, each version using more sophisticated methods to estimate the probability that a vehicle will be a high emitter. The final version is a working model that has been embedded into the vehicle information database (VID) developed by MCI to track inspections of all vehicles in California. This model is able to profile vehicle emissions at a rate of approximately 200,000 vehicles per hour.

The report entitled *Profiling Vehicle Emissions with the High Emitter Profile Model* contains a detailed discussion of the HEP's ability to identify high emitting vehicles. A copy has been provided to you. BAR used their Sacramento prototype test facilities to validate the HEP. Specifically, BAR targeted the dirtiest 7.5% of the fleet as identified by the HEP to be tested at the prototype test stations. In addition, BAR randomly selected an additional 2% of the fleet for testing. HEP selected vehicles *failed* the smog inspection 72% of the time while only 27% of the randomly selected vehicles failed. BAR expects increased accuracy in future models.

Radian also investigated using a hybrid of the HEP model termed low emission profile (LEP) model to identify vehicles that are likely to have low emissions and could therefore be waived from compliance or subjected to less stringent test requirements. The LEP model proved to be very effective at identifying vehicles that will pass the emission test. Using statistical analysis techniques that Radian evaluated during the development of the California HEP/LEP model, a new version of the LEP model was developed using IM240 data from Arizona's centralized I/M program. So far, this model profiles vehicle emissions strictly on the basis of failure rates observed in the Arizona IM240 program. Failure probabilities have been developed for specific combinations of model year, make, engine size, fuel induction system (carb vs FI), and emission control systems.

The Arizona LEP only requires the input of the vehicle identification number (VIN) to profile vehicle emissions characteristics. Radian's VIN Decoder decodes the VIN to identify specific parameters describing the engine, emission control system, and fuel induction system of the vehicle. These parameters are then related to IM240 failure probabilities derived from the Arizona program. Using these failure probabilities, the LEP model ranks vehicles in terms of lowest to highest chance of failing the IM240 test. Future versions of the Arizona LEP model could use information on remote sensing results on specific vehicle as well as the previous I/M test results for the specific vehicle to further refine its estimates of vehicle emissions. However, despite the lack of remote sensing results or previous I/M results, the Arizona LEP model is effective at identifying vehicles that are likely to pass the emission test.

Figure 1 shows the effectiveness of the Arizona LEP model at screening-out clean vehicles. We calculated the percent of vehicles that were screened out that were classified as high, very high, and super emitters for hydrocarbons (HC). Very-high and super emitters show the greatest I/M benefits, so a clean screen program should not be exempting large percentages of them. We used the California Air Resources Board (CARB) definition of emitter regimes to classify the vehicles. These regimes are shown in Table 1. The cleanest 50% of the fleet identified by the Arizona HEP model contained less than 5% of the very highs and supers for HC. The performance for oxides of nitrogen (NO_X) was close to the performance for HC (Figure 2). The cleanest 50% of the fleet contained less than 7% of the very high and super NO_x emitters. Profiling both HC and NO_x emissions is difficult because of the lack of correlation between excessive HC emissions and excessive NO_x emissions. Still, the model performance is impressive. CO emission performance is shown in Figure 3. Again, the cleanest half of the fleet contains a small fraction of the high emitters.

Table 1 – Emission Regime Definitions-- CARB

Regime	Multiples of FTP Standards		
	HC	CO	NO_x
High	2-5x	2-6x	2-3x
Very High	5-9x	6-10x	3-4x
Super	>9x	>10x	>4x

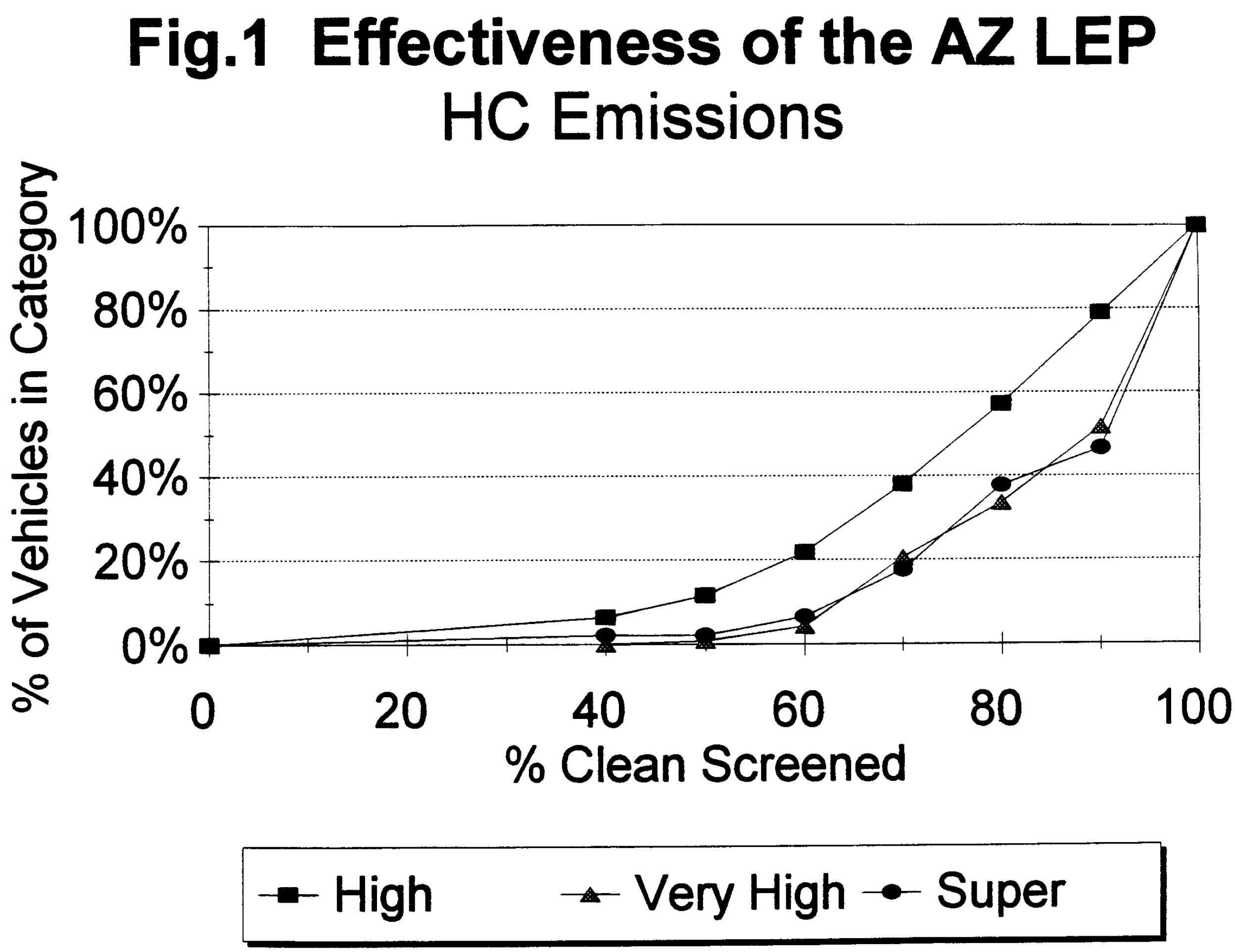
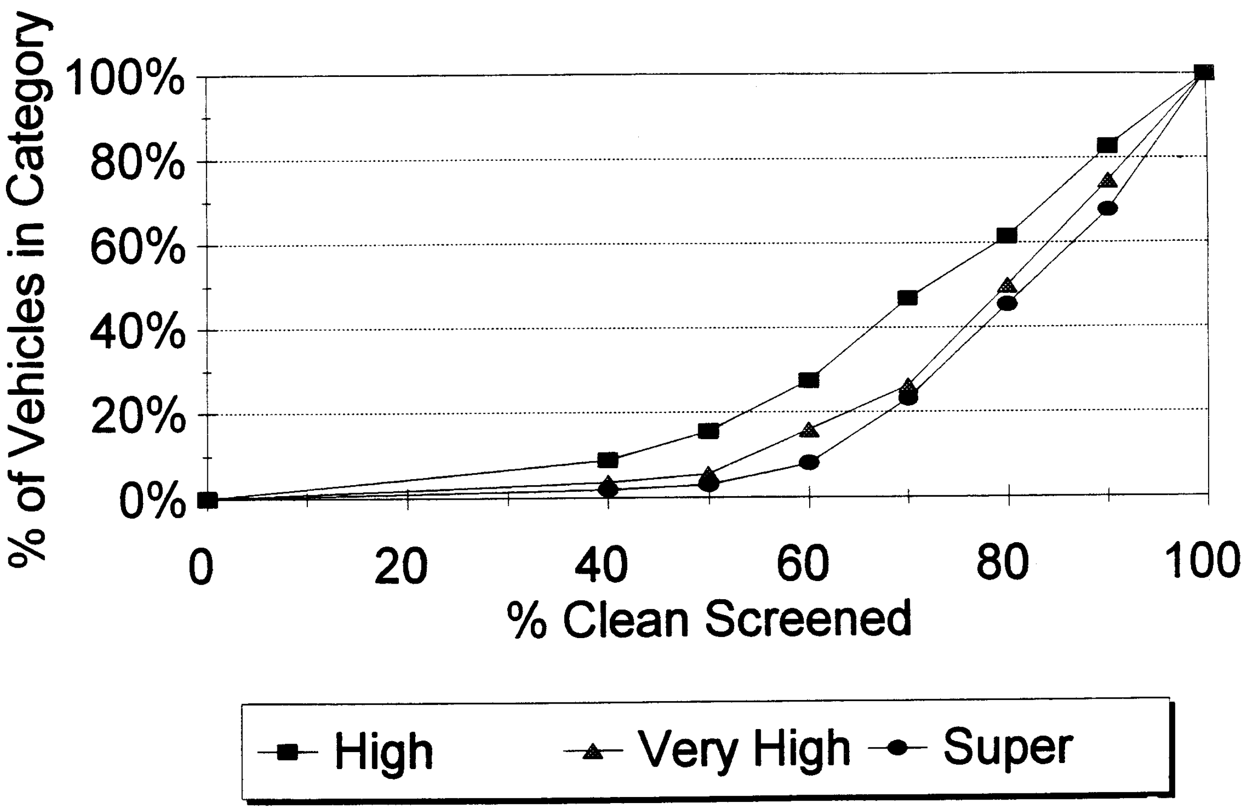


Fig.1 Effectiveness of the AZ LEP
HC Emissions
% of Vehicles in Category
100%
80%
60%
40%
20%
0%
0
20
40
60
80
100
% Clean Screened
High
Very High
Super

Fig.2 Effectiveness of the AZ LEP
NOx Emissions



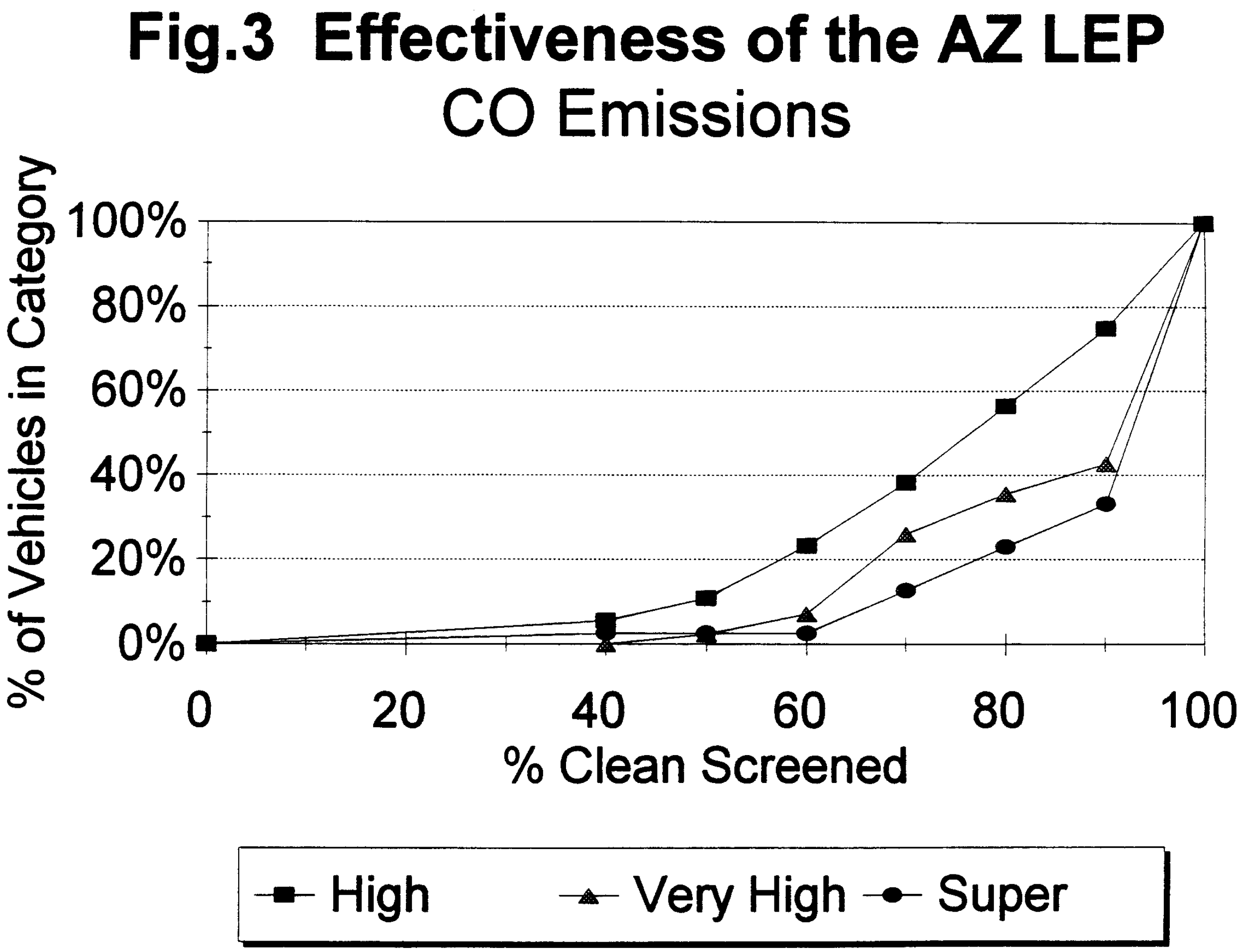


Fig.3 Effectiveness of the AZ LEP
CO Emissions
% of Vehicles in Category
100%
80%
60%
40%
20%
0%
0
20
40
60
80
100
% Clean Screened
High
Very High
Super

APPLICATION OF THE ARIZONA LEP MODEL TO THE COLORADO FLEET

To formally evaluate the Arizona LEP model, vehicles tested in Colorado=s IM240 program were profiled. We restricted the Colorado data set to initial tests. We then compared the performance of the Arizona LEP model as applied to the Arizona fleet with the performance to the Arizona LEP model, as applied to the Colorado fleet. We specifically investigated whether or not the Arizona LEP model, as applied to the Colorado fleet will show the same effectiveness in identifying vehicles in different emitter categories. Figures 4, 5 and 6 compare the effectiveness of the Arizona LEP model in identifying highs, very highs, and super HC emitters in both the Arizona and Colorado fleets. The performance is almost identical for both fleets. In both cases, the cleanest 50% contain less than 10% of the high, very high and super emitters. We also found similar performance in terms of percent of IM240 failures identified (Figure 7).The cleanest 50% contain less than 10% of the IM240 failures. We conclude that an LEP model derived using IM240 data from one state can accurately profile vehicle emissions for another non-California state.

ASSESSING THE USE OF THE LEP IN SCREENING OUT CLEAN VEHICLES FROM INSPECTION REQUIREMENTS

dKC estimated the emissions impact of a clean screen program by calculating the percent of excess emissions contained in the fraction that will be tested. This is consistent with EPA=s approach to assessing emission benefits of alternative test scenarios. We defined excess emissions as IM240 emissions above EPA=s final IM240 cut points. Using the Arizona LEP model, we calculated the percent of excess IM240 emissions in the Colorado data set that would be contained in different targeted fractions. Colorado=s IM240 program exempts vehicles less than 4 years old from periodic inspection requirements, so it is an appropriate data set to evaluate the impact of a clean-screen program in an area that exempts the newest 3 or 4 model years. Table 2 presents the results of the analysis. Exempting 50% of the vehicles from inspection requirements would result in a 5.5% loss in HC benefits, a 5.7% loss in CO benefits, and a 6.8% loss in NO_x benefits.

PROFILING EVAPORATIVE EMISSIONS

The LEP model is intended to identify vehicles that are likely to pass an exhaust emissions test. We analyzed Delaware=s tank test data to determine the percent of vehicles that fail the tank and gas cap tests that would be exempted based on the emission profile derived from the current Arizona LEP model. We found that the model has a slight preference towards identifying vehicles that are likely to pass the tank test. For example, the 50% cleanest fraction, based upon the Arizona LEP model, contained 34% of the tank test failures and 35% of the gas cap failures. Results are summarized on Table 3. In the future, dKC and Radian intend to analyze data from Delaware=s evaporative test program to determine if predictions of the probability of failing the tank test can be improved.

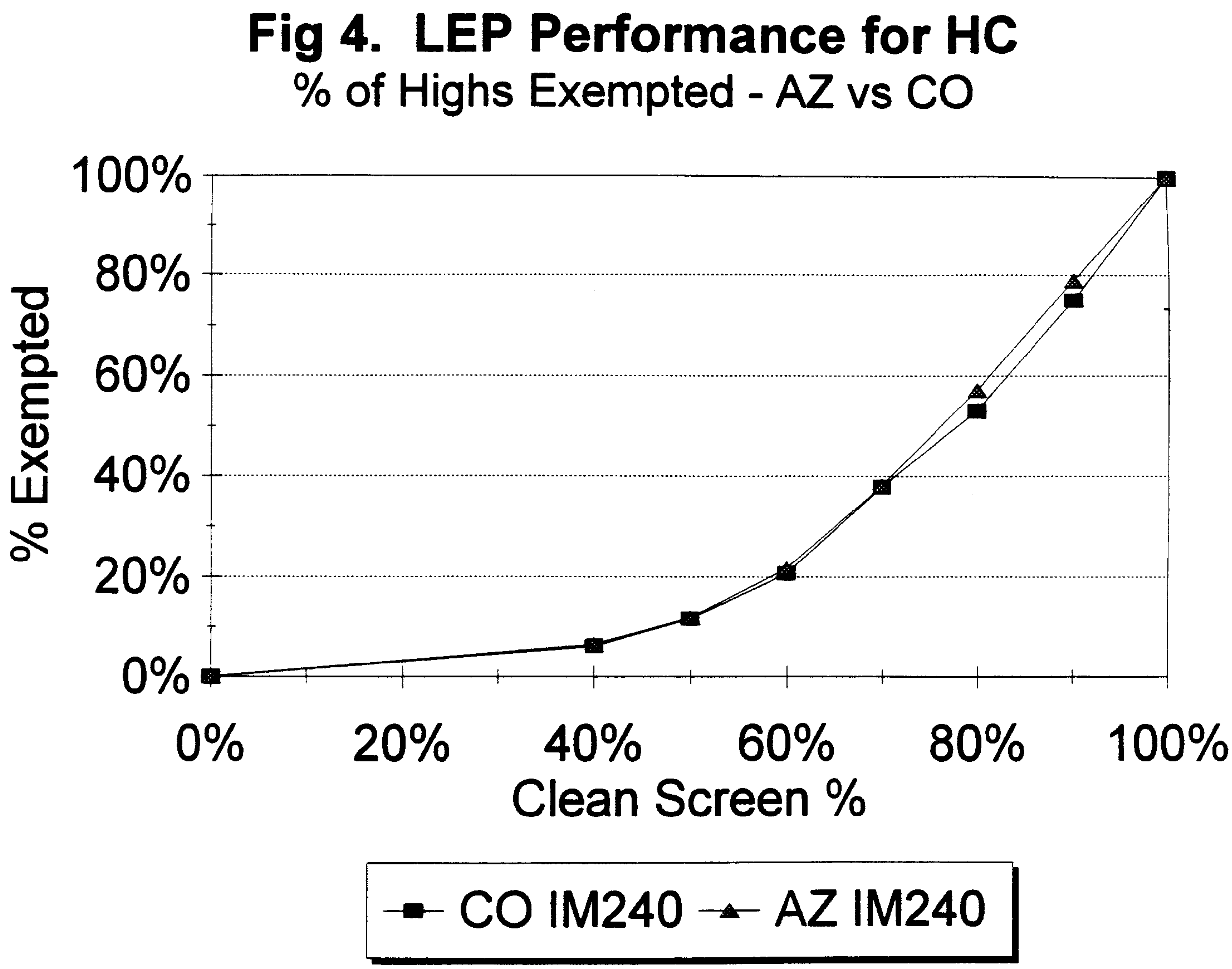


Fig 4. LEP Performance for HC
% of Highs Exempted - AZ vs CO
100%
80%
60%
40%
20%
0%
% Exempted
0%
20%
40%
60%
80%
100%
Clean Screen %
CO IM240
AZ IM240

Fig. 5 LEP Performance for HC

% of Very Highs Exempted -- AZ vs CO

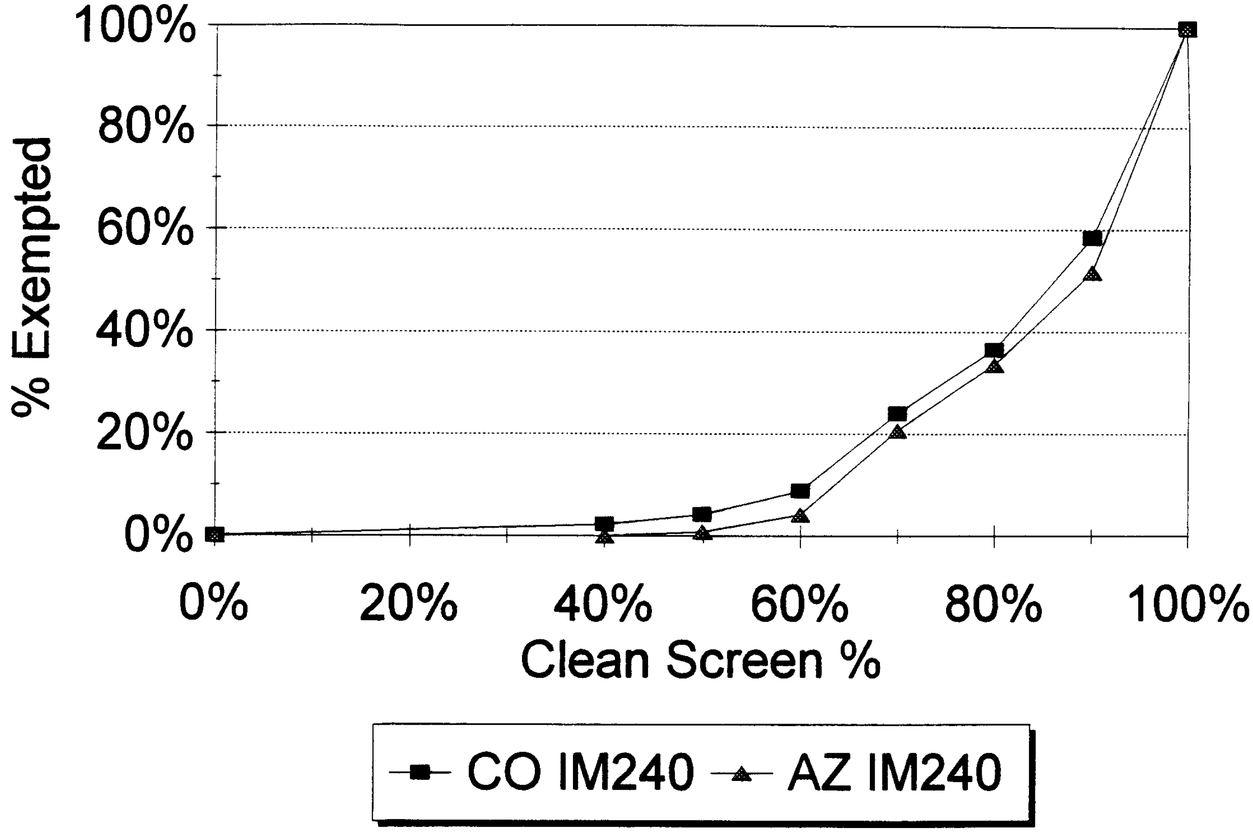


Fig. 6 LEP Performance for HC

% of Supers Exempted -- AZ vs CO

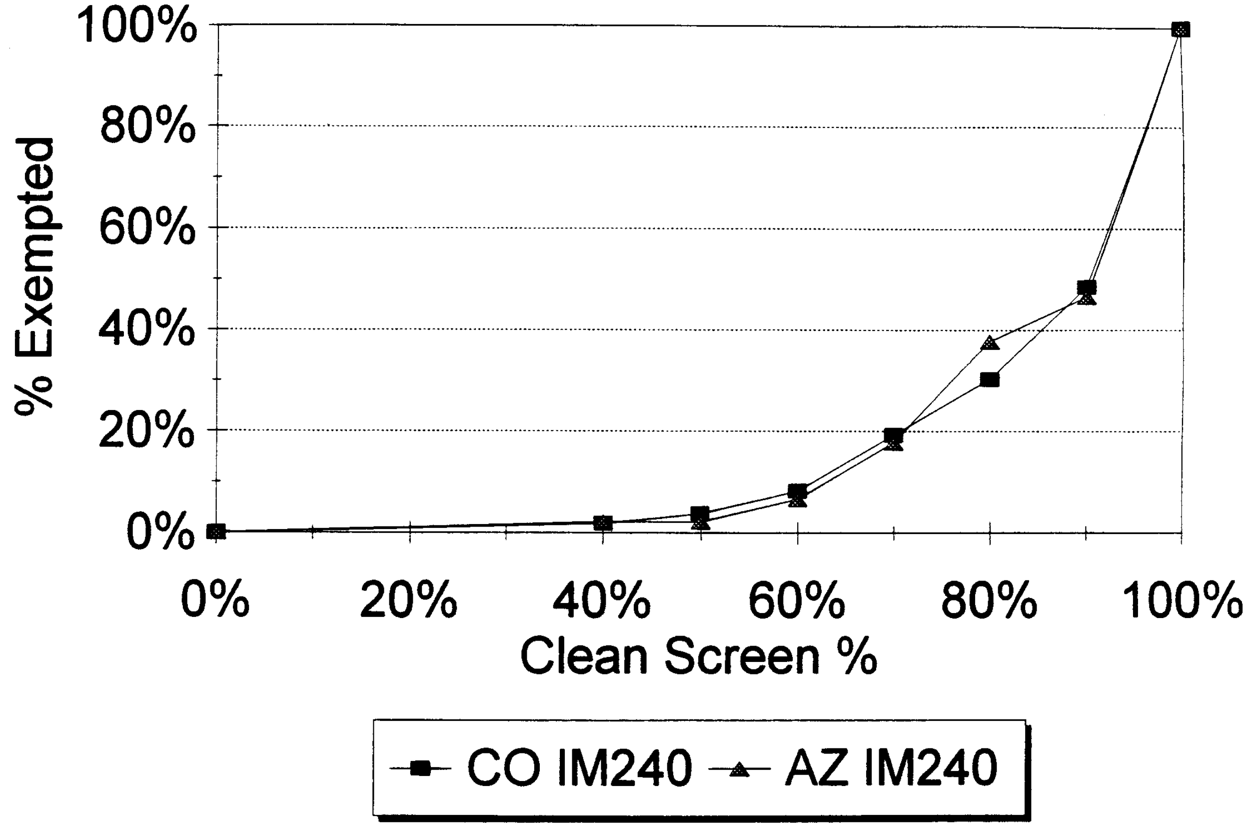


Fig. 7 LEP Performance -- AZ vs. CO

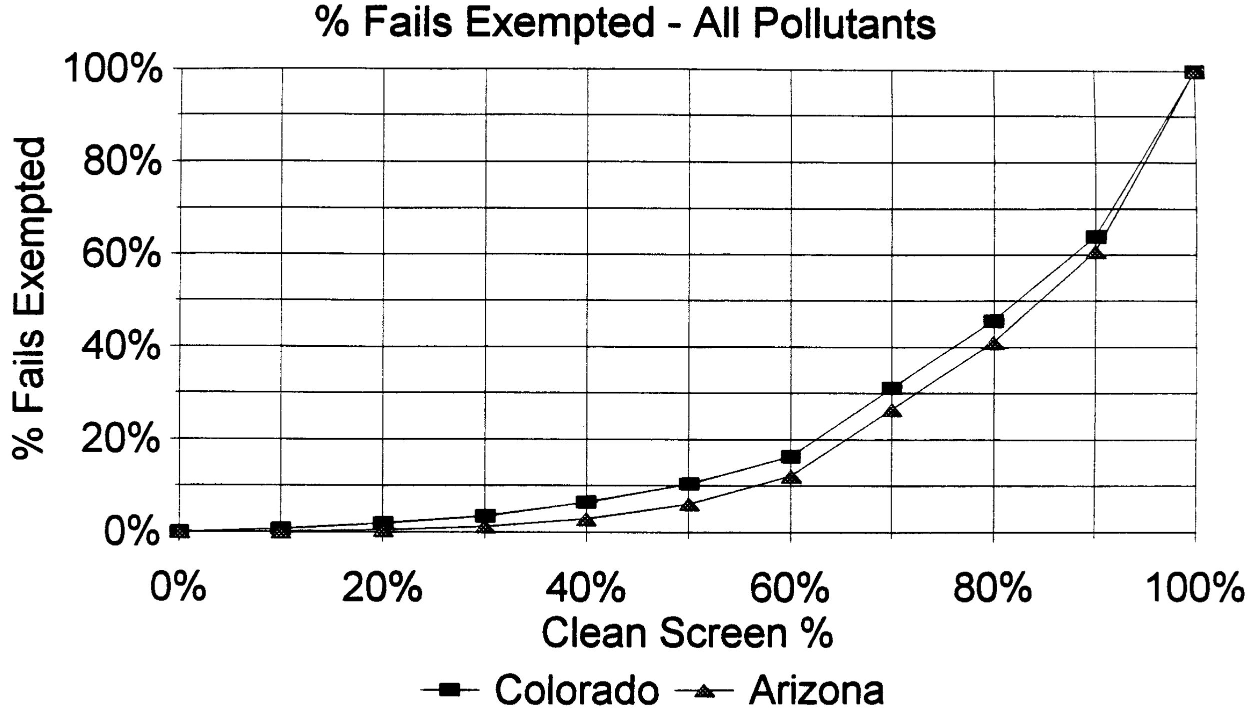


Table 2. Emission Impacts of Targeting with the LEP

Fraction Exempted	% of Excess Emissions in Exempted Fraction [1]		
	HC	CO	NO_x
0%	0.00%	0.00%	0.00%
10%	0.23%	0.30%	0.26%
20%	0.65%	0.80%	0.73%
30%	1.45%	1.75%	1.57%
40%	2.93%	3.58%	3.41%
50%	5.46%	5.71%	6.79%
60%	10.98%	10.28%	12.32%
70%	24.90%	23.21%	25.90%
80%	37.72%	35.10%	38.98%
90%	57.69%	53.08%	62.30%
100%	100%	100%	100%

Table 3. Impact of Profiling on Tank and Gas Cap Test Failures

Fraction Exempted	Percent of Tank Test Failures in Exempted Fraction	Percent of Gas Cap Failures in Exempted Fraction
0%	0.00%	0.00%
40%	26.85%	25.71%
50%	33.56%	35.13%
60%	41.97%	43.12%
70%	53.70%	54.39%
80%	69.06%	69.31%
90%	83.54%	83.96%
100%	100.00%	100.00%

HEP/LEP PERFORMANCE BY MODEL YEAR GROUP AND EMITTER CATEGORY

[1]Exhaust emissions in excess of Final IM240 cutpoints.

Vehicles tested in Colorado's IM240 program were profiled using the Arizona HEP/LEP model. The performance of the model is shown in Tables 4 and 5. Table 4 shows the percentage of each emitter category/model year group identified by the model at each targeting level. Table 5 shows the number of vehicles in each of the model year group/emitter category bin. We used the MOBILE5 emitter category definitions as described in Table 6. We found that the HEP model does show a preference to identify high, very high, and super emitters and does not identify normal emitters for all model year groups. In general, a higher fraction of the older model year group (82-85) is included in the targeted group than the 86-89 group or the 90+ model year group.

Table 4. Percent of Vehicles in Each Emitter Category by Model Year Groups

MY Group 82-85								
	Emitter Categories							
Targeting Level	Normal Low NOx	High Low NOx	Very High Low NOx	Super Low NOx	Normal High NOx	High High NOx	Very High High NOx	Super High NOx
10%	32.10%	26.12%	51.03%	75.39%	54.82%	42.19%	59.51%	70.73%
20%	64.04%	60.16%	76.84%	89.08%	84.28%	73.84%	85.15%	91.06%
30%	74.82%	72.84%	83.44%	92.88%	89.52%	84.34%	90.07%	95.93%
40%	97.88%	97.24%	99.56%	99.81%	99.86%	99.19%	99.80%	100.00%
50%	100.00%	99.82%	99.99%	100.00%	100.00%	99.96%	100.00%	100.00%
60%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
70%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
80%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
90%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
100%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

MY Group 86-89								
	Emitter Categories							
Targeting Level	Normal Low NOx	High Low NOx	Very High Low NOx	Super Low NOx	Normal High NOx	High High NOx	Very High High NOx	Super High NOx
10%	1.32%	4.65%	7.23%	5.79%	3.13%	4.63%	6.32%	7.46%
20%	10.84%	17.63%	24.79%	28.24%	22.88%	28.46%	29.83%	35.82%
30%	28.05%	43.46%	50.37%	56.25%	42.53%	54.44%	57.03%	56.72%
40%	44.57%	64.60%	73.76%	77.55%	65.47%	74.66%	79.84%	89.55%
50%	63.17%	81.37%	87.45%	88.43%	84.11%	87.16%	91.72%	91.04%
60%	77.92%	91.11%	93.47%	93.29%	92.55%	95.00%	96.78%	94.03%
70%	95.04%	98.49%	98.80%	98.61%	99.19%	99.18%	99.07%	100.00%
80%	98.93%	99.55%	99.65%	99.77%	99.79%	99.85%	99.61%	100.00%
90%	99.58%	99.74%	99.89%	100.00%	99.79%	99.85%	99.71%	100.00%
100%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

MY Group 90+								
	Emitter Categories							
Targeting Level	Normal Low NOx	High Low NOx	Very High Low NOx	Super Low NOx	Normal High NOx	High High NOx	Very High High NOx	Super High NOx
10%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
20%	0.71%	2.54%	4.06%	13.45%	1.66%	3.70%	6.41%	0.00%
30%	3.17%	10.72%	14.40%	26.05%	13.64%	24.22%	22.41%	0.00%
40%	4.41%	13.84%	18.82%	32.77%	15.68%	28.80%	27.67%	0.00%
50%	11.37%	35.86%	44.70%	66.39%	25.31%	47.71%	55.26%	33.33%
60%	23.42%	52.59%	61.62%	78.99%	55.11%	65.83%	72.80%	33.33%
70%	35.96%	64.44%	72.17%	84.03%	68.91%	80.10%	83.46%	33.33%
80%	55.59%	80.26%	85.89%	93.28%	88.12%	90.94%	92.58%	66.67%
90%	77.49%	92.69%	94.13%	100.00%	97.00%	98.44%	97.30%	66.67%
100%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

* Note: Dataset has 395,418 observations

Table 5. Number of Vehicles in Each Emitter Category by Model Year Groups

MY Group 82-85								
	Emitter Categories							
Targeting Level	Normal Low NOx	High Low NOx	Very High Low NOx	Super Low NOx	Normal High NOx	High High NOx	Very High High NOx	Super High NOx
10%	408	3294	16855	815	387	2301	11174	87
20%	814	7588	25378	963	595	4027	15988	112
30%	951	9187	27558	1004	632	4600	16913	118
40%	1244	12264	32882	1079	705	5410	18740	123
50%	1271	12589	33024	1081	706	5452	18777	123
60%	1271	12612	33028	1081	706	5454	18777	123
70%	1271	12612	33028	1081	706	5454	18777	123
80%	1271	12612	33028	1081	706	5454	18777	123
90%	1271	12612	33028	1081	706	5454	18777	123
100%	1271	12612	33028	1081	706	5454	18777	123

MY Group 86-89								
	Emitter Categories							
Targeting Level	Normal Low NOx	High Low NOx	Very High Low NOx	Super Low NOx	Normal High NOx	High High NOx	Very High High NOx	Super High NOx
10%	970	897	1351	25	193	334	440	5
20%	7968	3405	4631	122	1413	2053	2078	24
30%	20623	8392	9409	243	2626	3927	3973	38
40%	32766	12473	13777	335	4043	5386	5562	60
50%	46438	15712	16334	382	5194	6288	6389	61
60%	57281	17592	17459	403	5715	6853	6742	63
70%	69872	19018	18455	426	6125	7155	6901	67
80%	72734	19223	18613	431	6162	7203	6939	67
90%	73207	19259	18658	432	6162	7203	6946	67
100%	73517	19309	18679	432	6175	7214	6966	67

MY Group 90+								
	Emitter Categories							
Targeting Level	Normal Low NOx	High Low NOx	Very High Low NOx	Super Low NOx	Normal High NOx	High High NOx	Very High High NOx	Super High NOx
10%	4	0	0	0	0	0	0	0
20%	1188	215	319	16	31	71	83	0
30%	5348	908	1133	31	255	465	290	0
40%	7422	1172	1480	39	293	553	358	0
50%	19150	3037	3516	79	473	916	715	1
60%	39458	4454	4847	94	1030	1264	942	1
70%	60579	5458	5677	100	1288	1538	1080	1
80%	93652	6798	6756	111	1647	1746	1198	2
90%	130552	7851	7404	119	1813	1890	1259	2
100%	168466	8470	7866	119	1869	1920	1294	3

* Note: Dataset has 395,418 observations

Table 6. Emitter Category Groupings

Normal Emitters	<2 * HC Standard and <3 * CO Standard
High Emitters	>2 * HC Standard or >3 * CO Standard
Very High Emitters	>4 * HC Standard or >4 * CO Standard
Super Emitters	>10 g/mi HC or >150 g/mi CO
For each emitter category	Low NO_x < 2 * Standard High NO_x > 2 * Standard

Emission Standards (g/mile)			
	HC	**CO**	**NO_x**
82-93	0.41	3.4	1.0
94+	0.25	3.5	0.4