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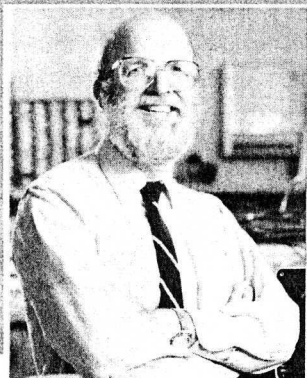


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# EPA Overestimates the Benefit of Biennial Inspection and Maintenance



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## ABSTRACT

The United States Environmental Protection Agency (EPA) computer model of mobile source emissions is used to estimate the benefits of future emissions control programs. Four input assumptions are discussed, each of which tends to overestimate the benefits of biennial testing programs. The assumptions are: each model year drives the same number of miles; high/superemitters, absent initially, increase linearly with mileage; inspection and maintenance (I/M) readings are invariant, and I/M repairs last forever. States opting for these programs should be aware that the predicted benefits may not materialize.

## INTRODUCTION

The benefits of I/M programs are estimated by means of a computer model (TECH5/MOBILE5), which is basically a large spreadsheet initially designed to estimate on-road emissions inventories based upon Federal Test Procedure results.<sup>1,2</sup> There are four model assumptions which appear to overestimate the benefits of biennial I/M, while there appear to be no compensating counterassumptions. Other models which

do not include all of these assumptions predict significantly lower benefits.<sup>3,4,5</sup>

### Each Model Year Drives the Same Number of Miles

In TECH5 the number of abnormal emitters, high and superemitters, is estimated as a function of the mileage accumulation. Overall average emissions are then calculated as a function of mileage accumulation. For each model year, emissions are assumed to have an average starting value and an average rate of deterioration for each 10,000 miles driven, and each model year is assumed to drive the same (decreasing) number of miles each calendar year. This assumption allows the model year to be substituted for mileage in the spreadsheet and the assumed average emissions to be multiplied by the assumed average miles driven. This is an error. There is actually a very wide range of miles driven by vehicles in a given model year.

Pennsylvania roadside surveys found three-year-old cars with odometer readings varying from less than 10,000 to over 150,000 miles.<sup>5</sup> If the EPA is correct that deterioration is based on how many miles are driven, then it is incorrect to separately average the miles and the emissions. For example, a vehicle driven 100,000 miles per year will, when only two years old, have very high emissions according to the model, and continuing high mileage on that vehicle will dominate the emissions picture (in algebraic terms  $\sum \bar{a} * \bar{b}$  is always less than  $\sum a * b$  when a and b are positive variables with wide distributions.) This error causes the MOBILE5 model to underestimate fleet emissions even if correct average miles per year and average emissions per mile are input. This

underestimate, pointed out by Pollack et al.<sup>7</sup> leads automatically to an overestimate of the percentage benefits from an emission reducing I/M program. This model structure also necessarily eliminates from consideration any relatively new but high mileage vehicles which could be identified and repaired were they subject to an I/M program. Colorado currently exempts the first four years of vehicle life from its I/M 240 program because of the EPA model.<sup>8</sup> On-road data from California<sup>9</sup> show that the badly maintained 20 percent of vehicles less than five years old (7.5 percent of the vehicles) contributed 12 percent of the total HC and 10 percent of the total CO.

### Superemitters Are Absent at Zero Miles and Increase Linearly with Mileage

Glover and Brzezinski<sup>2</sup> state, "The methodology assumes that no Superemitters exist at zero miles. Also, the rate of occurrence of Supers is assumed to increase linearly with mileage." Figure 1 shows the EPA data from which this conclusion is derived. Notice that they clearly state that the line through the origin (as required by the model and placed through the center of gravity of the data) is in fact an assumption. This assumption can be questioned. Calculated correlation lines using the EPA data for CO and HC, have large intercepts on the y axis (a large fraction of superemitters at zero miles) and the lines slope down for CO and up for HC but the slopes are without significance ( $r^2$  less than 0.03). Assumption of a steep slope in the model where none exists in the data causes a large fraction of older (and thus assumed higher mileage) vehicles to be modeled as high or superemitters. This, in turn, ensures an

overestimate of I/M benefit because most of the assumed high and superemitters are modeled to be correctly failed by an IM 240 (or indeed an idle) I/M test.

According to a recent report,<sup>10</sup> when a large number of vehicles were measured in late 1994 by means of IM 240 in Sacramento, CA, almost all 1994 models were low emitters and 75 percent of 1983 models were found in the low category. This contrasts to the EPA model which predicts<sup>11</sup> that only 22 percent will be low emitters. This apparent error allows the model to predict an 80 percent failure rate for such models, and thus to predict large I/M benefits which will not materialize if only 25 percent are actually high emitters.

**I/M Readings are Invariant**

There is an implicit assumption that I/M readings, especially by means of IM 240, somehow represent "the truth" in terms of the emissions of the tested vehicle. Probably the single most important result of the Auto-Oil study, and the result least discussed because it does not fit the paradigm is that broken modern vehicles, when tested repeatedly using the full Federal Test Procedure<sup>12</sup> with the same fuel, show HC emissions readings which average fifty times more than those of well-controlled vehicles. More

importantly the readings vary (apparently by randomly changing air/fuel ratio) in such a way that the factor of two to 10 variations in the FTP emissions of the broken cars exceeds by more than an order of magnitude the relatively subtle effects of fuel variation, which the study was designed to address. As shown in a recent report,<sup>13</sup> IM 240 tests, idle tests, and on-road remote sensing tests share the same tendency, i.e., highly variable readings are observed for broken vehicles. Apparently the computer control systems are "out of control" and this affects the air/fuel ratio. All the evidence suggests that these vehicles, known as flippers, are broken and need repair. The I/M problem with variable emission vehicles is that owners are likely to find out that they own flippers. Most biennial programs supply one free retest for every test failed. If a flipper has a 50 percent chance of passing an IM 240 test at a (two) test cost of \$25, then four tests would only cost \$50 and the probability of passing one of the four without any significant repair is 93.7 percent. That is a bargain compared to a \$450 potential repair bill.

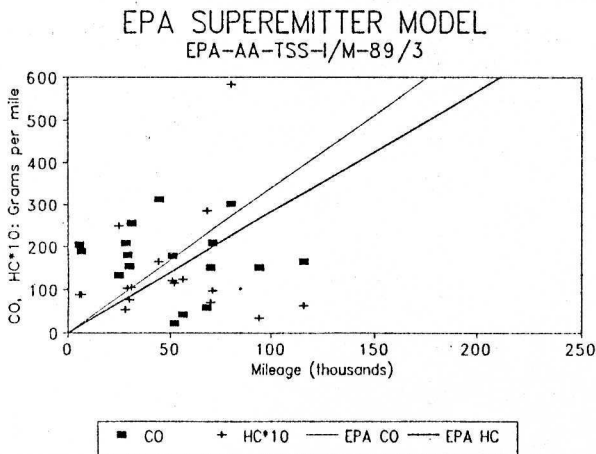
Once again this phenomenon will greatly bias the modeled I/M benefits. Flippers lower the percentage of vehicles that actually get repaired while nevertheless maintaining an apparently high initial failure rate. This phenomenon also

leads to apparent emissions reductions because the first failed test is always higher than the last passed test even though no repairs have been performed.

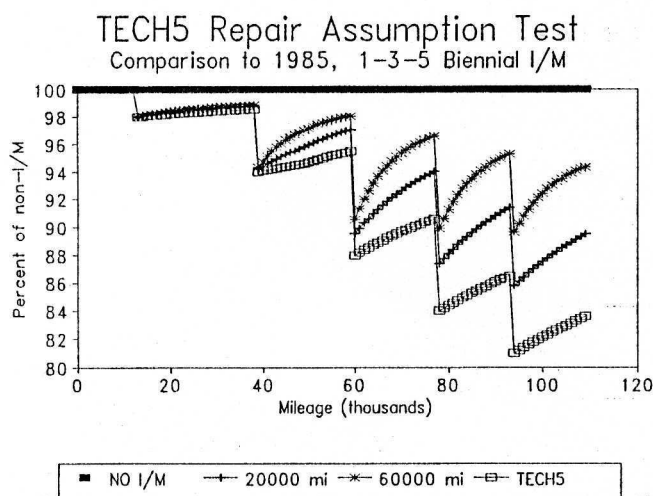
**I/M Repairs Last Forever.**

Glover and Brzezinski<sup>2</sup> state, "It is assumed that the fleet, after repairs, will have the same emissions deterioration as before repairs." The fact that EPA modeled repairs last essentially forever was noted by Harrington and McConnell<sup>3</sup> as a potential source of significant error. To evaluate the size of that error alone I have estimated the benefits if the repairs last for two, or alternatively for six years. That evaluation is illustrated in Figure 2. The top line in Figure 2 is the line provided by EPA for 1985 vehicles without I/M. The bottom line, displaced by the biennial steps, is a close approximation to the EPA assumption described by Glover and Brzezinski.<sup>2</sup> Notice how the EPA model assumes that I/M benefits accumulate year after year. The lines in between are derived from assuming that 90 percent of the repairs only last for about two and six years, respectively. The calculation actually estimates that repairs degrade exponentially with the first order of magnitude of loss occurring in 20,000 and 60,000 miles, respectively. Note that the EPA assumption of "essentially forever" is evident since even the six-year repair calculation does not come close to the EPA assumed line.

There are two sources of evidence as to the likely lifetime of repairs. Lawson has analyzed the lifetimes of repairs performed to pass the California decentralized I/M program.<sup>14</sup> The result was that repair lifetimes longer than one day could not be detected. No regularly scheduled I/M program would have significant predicted benefit under these circumstances. Scherrer and Kittleson's evidence<sup>15</sup> that the centralized Minnesota program has no significant effect confirms this prediction. Brown et al.<sup>16</sup> have studied repairs performed when the owner and repair facility have no incentive to cheat. In that study they showed that repairs generally last longer



**Figure 1.** Data plotted from Glover and Brzezinski.<sup>2</sup> The lines are the assumptions used by the current EPA model.



**Figure 2.** Results of a numerical simulation of the EPA TECH5 model result for 1985 vehicles. The top line is the "without I/M" line from Glover and Brzezinski<sup>2</sup> Figure 3.2 set to 100 percent throughout the deterioration lifetime. The bottom line is the "with I/M" line from the same source. Two intermediate repair lifetime calculations have been added (the two intermediate lines).

than three years (with the exception of one owner who tampered with his vehicle). The conclusion to be drawn from this evidence is that a program that rewards owners who can create low emissions readings for one day, with a pass good for two years, will lead to exactly that behavior.

In the calculation illustrated by Figure 2, after 10 years, the vehicle has driven 109,000 miles and the emissions reduction from the EPA I/M model (with I/M relative to without) is 16 percent. This is the difference between the top and bottom lines. The 20,000 mile repair assumption leads to an I/M benefit estimate of only 6 percent. The 60,000 mile repair assumption leads to an 11 percent predicted I/M benefit, both significantly lower than the EPA model.

Underestimating overall emissions by means of incorrect averaging and eliminating newer gross polluters from testing will certainly lead to an overestimate of potential benefits. Assuming, without benefit of correlated evidence, that high and superemitters accumulate linearly with increasing mileage (for which model year is assumed a perfect surrogate) overestimates the benefits of testing all older vehicles. Owners of flippers, without

cheating but merely by means of repeated testing, will sooner or later obtain a "pass" with a vehicle which should be repaired. In California we have estimated<sup>9</sup> that 20 percent of on-road emissions come from such vehicles. Rewarding "fixes" to "pass the test" will certainly result in such behavior. Unfortunately, owners frequently "unfix" the vehicle as soon as the test is passed.<sup>14</sup> States which opt into biennial I/M programs anticipating the benefits ascribed to them by EPA computer modeling might find that these benefits do not actually materialize. This would repeat history because the benefits modeled for the previous 10 years of I/M programs also failed to materialize when independently tested.<sup>9,15,17</sup> Caveats with the EPA MOBILE models are described in more detail in American Petroleum Institute Reports.<sup>18</sup>

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