Evaluation of the Effectiveness of On-Board Diagnostic (OBD) Systems in Identifying Fuel Vapor Losses from Light-Duty Vehicles
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Prepared by: Eastern Research Group
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Comments by S.J.Stewart March 5th 2012

Issue

The issue of interest here is whether it is possible to use real-world OBD data regarding the evaporative emissions performance of in-use vehicles as an input to inventory modeling. One commonly available source of data is the OBD data from I/M programs. But can this data provide a direct indication of the evaporative performance of in-use vehicles? For this study the measure of actual evaporative performance was SHED (or PSHED) testing. Its results are on a continuous scale; however in this study they were divided into just 'high' and 'low', but with two different cut-points between the designations. The OBD results are simpler in that they are 'yes/no' data; either there were evaporative trouble codes, or there were not. So the question comes down to the correlation between 'high/low' on the SHED results and 'yes/no' on the presence of evaporative trouble codes.

Pre-Screening

The first thing to note is that participant vehicles were screened using RSD, so that only those likely to have high evaporative emissions participated. So the study tells us nothing about the prevalence of OBD evaporative trouble codes in vehicles that were deemed unlikely to have high evaporative emissions. The data do show that all participants with evaporative DTCs did have high SHED results, but that is simply to be expected if the pre-screen was effective. This leaves wide open the question of whether an OBD evaporative DTC is a good indicator of high evaporative emissions.

Because DTCs are not cleared until 40 warm-up cycles have occurred without re-occurrence of the problem indicated by the DTC, there is clearly a possibility that the presence of an evaporative DTC does not indicate a current evaporative problem, but only that one did exist at some recent time. For this study the pre-screen sought to ensure that only high evaporative vehicles were likely to participate, and only 'hard' DTCs (with MIL on) were considered. Future investigations might also include vehicles that would have been screened out from this study, and also those with 'pending' evaporative DTCs.

The RSD pre-screen does not appear to have been very effective. Out of 149 cases shown in Tables 3.3 and 3.4, only 27 had evaporative emissions over 0.3g/Qhr, and only 20 were over 1.0g/Qhr. So only about one in six, or one in seven were correctly screened by the RSD-based index. The benefit of this ineffective pre-screen is that the sample did in fact include a large number of vehicles that did not have high evaporative emissions, and it is nice to see that they also had (almost) no evaporative DTCs.

SHED vs. OBD

SHED results indicate the total rate of evaporative emissions from a vehicle but tell us nothing to help pinpoint where on the vehicle is the source of those emissions. This is in complete contrast to OBD

systems which test only specific aspects of the vehicle hardware and control system, and thus completely ignore all the other possible sources of evaporative emissions.

There are only two types of evaporative problem that OBD does detect: basic evaporative OBD only checks the canister purge solenoid and flow rate; and enhanced evaporative OBD also looks for vapour leaks equivalent to a certain size of hole. So high SHED results caused by liquid leaks or tailpipe residuals could never be detected by current OBD evaporative monitors.

Modified California Method

The study used the Modified California Method in an attempt to identify what might be the causes of poor correlation between SHED-high/low and OBD-yes/no. The MCM inspection tried to identify the source of the emissions, and also made a subjective assessment of whether the OBD system should have been able to detect the problem. The assessment is based on a non-intrusive investigation, which often did not pinpoint the source of evaporative emissions, so it is not certain that only vapour leaks were included – some cases may have been small liquid leaks into inaccessible locations, and from the comments it appears that in some cases the source could have been residual vapours from the exhaust system. So the deductions from the MCM tests are also somewhat speculative as well as being subjective. In guessing whether the leak should have been detected by OBD, they also assume that the OBD system would have had the chance to detect the problem, but this may not have been the case. It would be valuable to take the investigation further using an evaporative testing cart to measure vapour leaks rates.

Readiness

The issue of readiness is described in the report, and the focus of the results is on cases where the evaporative monitor was reported 'ready'. Experience with OBD data from the British Columbia I/M program indicates that the evaporative monitor is the one that is most unlikely to be 'ready' when a vehicle is presented for inspection [*], and it can also be the most difficult to reset after codes are cleared [†]. However, I/M programs have 'readiness criteria' which allow for one or more monitors to be 'not ready' at the time of inspection, and therefore I/M programs do not do much to ensure that evaporative monitors ever do actually run. For those vehicles where the evaporative monitor has not run, the OBD data is obviously unable to offer any clue as to the vehicles likely evaporative emissions.

Another aspect of readiness is pertinent to this study, in that once a monitor is set to 'ready' it will stay that way until the system is cleared using a scan-tool or power is removed. The monitor will only run when the right conditions are met, and this might not be very often. It could be that the evaporative monitor ran at some considerable time in the past and did not detect any problems; so it set its own status to 'ready' and stored no trouble codes. In the time since the monitor's readiness was recorded, a leak may have developed, but unless the enabling criteria were met, the monitor would not have run, and thus would not have even tried to detect the problem. In this case it is not valid to say that the OBD system should have detected the problem.

Results

Considering Tables 3.3 and 3.4; the four vehicles with evaporative DTCs did all have SHED results over 0.3g/Qhr, and three of them were over 1.0g/Qhr. So none of them were below 0.3g/Qhr. However, from

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[*] *In 2011 in BC there were 252,497 vehicles that received OBD inspections, from model years 1998 to 2004. The number where the evaporative monitor was 'not ready' was 46,650, or 17.7% of the total. The rates of 'not ready' for the other non-continuous monitors were CAT 9.4%; OXY 5.3%; HOXY 2.8%; EGR 6.0%*

[†] *When vehicles returned for re-inspection the EVAP monitor was not ready in 7,591 cases out of 14,537, which is 52.2%.*

the 149 participants, 129 vehicles were below 1.0g/Qhr and 122 were below 0.3g/Qhr, even though the pre-screen criteria sought to only include vehicles likely to have high evaporative emissions. This does not really support belief in the ability of the pre-screening system, using RSD, to identify probable high evaporative emitters.

One striking thing about the results presented in the report is how few vehicles made it from Tables 3.3 and 3.4 into Table 3.5. after eliminating cases where the evaporative monitor was 'not ready'; cases of 1996-1998 vehicles that only had basic evaporative monitoring; and liquid leakers, only ten cases remained from the twenty shown in Table 3.3; and only three of these had evaporative DTCs. This is hardly an adequate sample from which to draw compelling conclusions. Those three that had evaporative DTCs did have significant evaporative emissions, and the four vehicles with the lowest SHED results did not have evaporative DTCs, so there is some suggestion that the OBD evaporative monitor might not be sensitive enough to precisely identify when a leak might cause SHED results to exceed 1.0g/Qhr, and it could be that it would only detect bigger leaks. There are also the potential problems already described pertaining to when the monitor last ran, and these may also explain something about the three vehicles in the middle, where there were no evaporative DTCs but yet the SHED results were over 6 g/Qhr. It is also pertinent that two cases without evaporative DTCs did have other DTCs, and their presence may have blocked the evaporative monitor from running. This would definitely have been the case with the Toyota Camry because one of the evaporative monitor's enabling criteria is for the MIL to not be commanded 'on'. For the 1997 Mercury Villager, Alldata does not list any possible evaporative DTCs, which casts some doubt on whether this was in fact an enhanced evaporative OBD vehicle.

Conclusions

The conclusions of the report are substantially supported by the data presented, but they do come across as being a little dismissive of the usefulness or reliability of OBD data as an input for modeling the evaporative emissions of in-use vehicles. It is clear that they should only be one of a number of inputs. In truth OBD only tests a limited number of specific things, and only when other specific conditions are met.

The MCM inspectors' opinions regarding whether or not OBD should have detected a fault have very little value because they neither hunted down the exact source of leaks nor knew when the evaporative monitors had last run.

The sample that made it through to Table 3.5, does suggest that evaporative DTCs are an indicator of high evaporative emissions, but the number of cases that did not make it into Table 3.5 demonstrates that there are also other, very significant causes of high in-use evaporative emissions.

It would be tempting to conclude that when evaporative DTCs are present they do always indicate high evaporative emissions. Although this seems probable, the pre-screening criteria for participation in the study should have precluded that conclusion. But the pre-screening was ineffective and therefore does allow the conclusion that evaporative DTCs are very unlikely to be present if SHED results are low.

The SHED results clearly indicate that the pre-screening from RSD results is not a reliable way to identify vehicles that have high evaporative emissions. The efficacy of the pre-screen was not the point of the study, and while adding additional process, it did not add anything to the value of the results.

The small final data set of cases shown in Table 3.5 is really too small. Further work is necessary to enlarge this data set. The value of the data would be enhanced by improving on the MCM in order to be more precise regarding the source of emissions, and by removing the confusion of an ineffective pre-screen.

Other Points

There are some typographic, grammatical and other errors in the report.

Page 5, 1st para, last sentence: Needs to mention that P2 codes are also generic and some P3s.

Page 6, 2nd para, 10th line. The word 'likely' is used as an adverb, which it isn't. It needs to be replaced by 'probably'. This error also occurs twice in the sentence that starts on the 14th line of page 17; once in the 6th line of the 1st paragraph on page 18; and at the end of the 3rd to last line of page 19.

Page 6, start of section 2.3:

- Second bullet: Needs to include P2 and P3 codes, and needs to indicate that P2 codes are generic, as are some P3.
- Third bullet: Needs to include P#0, P#9, P#A, P#B and P#C

Page 7, last sentence in penultimate para: Says that the PCM will automatically erase codes after three consecutive tests -- but it actually needs 40 warm-up cycles.

Page 8, 2nd para, 3rd line: The word 'both' needs to be either moved or removed.

Page 8, 6th line of section 2.5: Needs to include 'psi' as the unit for RVP

Page 12, last para: There are also some generic evaporative trouble codes in the P2 and P3 ranges.

Page 14, 4th line: 'does' should read 'do'

Page 21, Table 4.1: This table is not really necessary. It only repeats information already presented in Table 3.5