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SUBJECT: Review of "Evaluation of the Effectiveness of On-Board Diagnostic (OBD) Systems in Identifying Fuel Vapor Losses from Light-Duty Vehicles" Version 9 dated February 17, 2012

This is an evaluation of Eastern Research Group's (ERG's) final report on evaluating the effectiveness of Second Generation On-Board Diagnostic (OBD) systems through a comparative analysis of evaporative emissions field data collected in the Denver area.

Several studies were performed through Cooperative Research and Development Agreements between the Assessment and Standards Division (ASD) within the Office of Transportation and Air Quality (OTAQ) of the United States Environmental Protection Agency (EPA) and the Colorado Department of Public Health and Environment (CDPHE), with support provided by ERG. Data was collected at the Denver, Lipan, and Ken Caryl Inspection and Maintenance (I/M) lanes using a Portable Sealed Housing for Evaporative Determination (PSHED) and remote sensing devices. Because the studies took place at existing I/M lanes, OBD information was also available for each vehicle.

The efforts span a four-year span covering 2008 – 2011 at three locations in and around Denver, Colorado as noted above. Since the CDPHE operates IM240 lanes capable of capturing exhaust gas readings and perform OBD II tests on 1996 and newer vehicles it was beneficial to also gather evaporative emissions on participating vehicles as well. These locations were also able to perform "SHED" testing which provided a unique opportunity to perform and gather data for this study. Since OBD II vehicles are equipped with constant-monitors and enhanced fuel metering systems the tailpipe emissions are extremely low by design. However, "vehicle emissions" don't come exclusively from the tailpipe of the vehicle but from a variety of sources. OBD II equipped vehicles are designed to monitor some potential non-tailpipe emission points such as fuel vapor leaks from the fuel storage system. When an OBD vehicle senses a possible leak in the vapor system the malfunction Indicator Light (MIL) is required to illuminate to warn the driver of the problem. In response to the MIL illuminating, the driver is supposed to effect repairs to correct the problem causing the elevated emissions. For the purpose of these studies it is fortunate that not all motorist pay attention to an illuminated MIL. If the illuminated MIL were heeded as expected by EPA, then none of the vehicles in the first two studies would have arrived with active DTCs. The responsive motorist with an illuminated MIL however may be the reason so few participating vehicles had any DTCs.

In the analysis section the assumptions regarding the OBD tests in the first two studies that were taken shortly before the SHED test or the previous day are valid in my opinion since very few vehicles change their emissions status over night. In the first two

studies the OBD was evaluated up to a day prior to the SHED testing. With OBD, however the MIL can illuminate on the next key cycle after an OBD evaluation has been performed but that does not mean that the emissions just exceeded the limits. In many cases the emissions have been elevated for up to several key cycles prior to the illumination of the MIL. No mention was made that any participating vehicle had the MIL off during the OBD II evaluation but illuminate after the OBD test during the SHED test(s).

The "Denver 2010" repair effectiveness study indicates 68 vehicles were recruited using RSD measurements around Denver. This document does not specifically state that the vehicles recruited by mail had very high RSD readings and were considered "gross polluters" or what threshold was the determining factor for selection but it does not make sense that "clean vehicles" would be solicited for the repair study. This group had a 100% OBD/SHED match rate presumably because the vehicles were recruited and all tests were performed on location during one visit, which is the ideal situation. The establishment of the PSHED at the Denver facility and correlating the readings to LSHED ensured that, for all practical purposes the readings are to be considered the same and was also a great benefit for the continuity of the study.

Review of the timeline of the several studies and the number of "dropped" tests indicates that as each study was completed and analyzed that lessons were learned and improvements were made before beginning the next study. These adjustments allowed all tests in the Denver 2010 study to be paired. This important due to the costs of performing the study of each vehicle in a study in terms of man-hours, expenses, and other costs not producing an end product. The summary in table 3-1 illustrates the point very well since the first set of data had a 29% dropout rate. This was cut in half in the following study to 14.6%, followed by a 0% dropout rate in the last (Denver) study.

Table 3-2 is an interesting study in the further filtering of questionable data. The percent of participating vehicles with the specific evaporative monitor ready was 95% (149/157). This high percentage of a "ready" is interesting to me given the mix of older vehicles in the study. It is widely accepted that the 1996 through 1998 model year OBD II systems did not easily get the evaporative monitor to a ready state. As a result the EPA allows up to two monitors to be not ready in the 1996 – 2000 model years. In fact vehicle HE-6725 had a faulty fuel cap that was not detected even though the monitor indicated it was ready.

Reviewing the two tables 3-3 and 3-4 the data indicates that if a vehicle is going to exceed the 0.3g/Qhr limits then it is very likely to exceed the 1.0g/Qhr as well. Out of 27 vehicles that exceeded the 0.3g/Qhr 20 also were in excess of the 1.0g/Qhr limit which is 74%. Review of the data in these two tables also indicates that 3 out of the 4 vehicles with an evaporative DTC were also over the 1.0g/Qhr, which is 75%. The data strongly suggests that if a vehicle is over the 0.3g/Qhr then it will more than likely be over 1.0g/Qhr as well. The data in these tables also suggest that if an evaporative DTC is set (MIL on) then the vehicle will definitely be exceeding the 0.3g/Qhr threshold and that it more than likely exceeds the 1.0g/Qhr as well. This finding indicates that when the OBD II system evaporative monitor is ready and has run and finds a problem (sets a code) there are definitely high measurable SHED emissions that can also be detected by RSD. This is a positive finding for programs that continue to perform RSD for program evaluation. It would lend credibility to RSD findings of "high emitters" regardless of the results of paired OBD records. This finding provides the reason why OBD II equipped vehicles that are

flagged as gross polluters by RSD will pass an OBD II inspection. This is something we have seen in Georgia in past years.

Unfortunately the findings also provide a strong indication there may be many vehicles with high emissions where the OBD II system has not identified an issue that it is supposed to be monitoring. Some factors to consider here are that the evaporative monitors have a lot of enabling criteria that must be met to allow it to "run". Ambient temperature greatly affects this monitor, as does the amount of fuel in the fuel tank. Given the current state of the economy many motorists only purchase small amounts of gasoline at each refueling due to the cost. This aggravates the evaporative monitor's ability in particular to become ready since the fuel level typically must be at least a quarter of a tank or more to enable the evaporative monitor to become ready and run. Another reason the errant emissions identified by RSD and measured by SHED testing are not identified by OBD II is that some emissions are due to leaks in systems not monitored or by liquid leaks such as oil, fuel, and high VOC content washer fluid (Atlanta Georgia has such a restriction).

In the evaluation report there is mention that 1981 and newer vehicles were asked to participate in at least some of the studies (Lipan, Caryl). OBD II vehicles began with 1996 model year. This difference in model years could be the reason why so many vehicles had no OBD readings to pair with SHED data, a loss of 29% and 14% in Lipan and Caryl studies. No specifics are given provided for the high drop out due to no OBD II readings, but this would certainly account for the high number. The RSD identified vehicles in the Denver study had a 0% drop out due to non-pairing presumably due to only 1996 and newer vehicles being sent recruitment letters.

Reviewing comments by inspectors performing the MCM two specific vehicles. Both LIP-254 and CRL-568 have the comment "Gas cap IM failure." In addition, HE-6725 has the comment "Gas cap was cause of leak." These comments infer that a fuel cap pressure test was used to determine the gas cap leak failure. No mention in the study is made with regard to the use of a separate fuel cap integrity test however 1975 and newer vehicles have this check done in Colorado according to information found on the OBD Clearinghouse website. If this is the case then only three vehicles had a leaking gas cap and one gas cap was missing (HE-6702) out of 180 vehicles. The OBD systems in these four early OBD II vehicles did not store an evaporative DTC because they do not have enhanced evaporative monitoring. This finding may result in non-enhanced evaporative monitored vehicles being given more weight as polluters in modeling due to their demonstrated lack of being able to identify high evaporative emissions or even the presence of a fuel cap at all.

Observing the results of the High and Low SHED Pairs data in table 3-6 it becomes apparent that newer vehicles (2004 and newer) have a definite ability to control evaporative emissions better than earlier years. This may be in part to lower mileage and partly due to manufacturers getting better at sealing fuel fittings. Older enhanced evaporative OBD II vehicles (2000-2003) show a fairly low number of high value pairs (10% - 14% over .3g/Qhr) while, as expected the oldest OBD equipped vehicles have the highest SHED numbers (50% over .3g/Qhr). This data also indicates a high number over 1.0g/Qhr for the

older OBD II vehicles with limited evaporative monitoring. This table illustrates the older OBD II vehicles certainly are the ones most likely to be the vehicles identified by RSD and as a percentage of their model year have a large amount of evaporative leaks undetected. As a group, the older OBD II vehicles contribute more evaporative emissions than newer and should be given a higher weight when calculating emissions from the fleet. Not all OBD vehicles were created with the same abilities to monitor the various systems, which is an understatement, but the reality is that there are tens of thousands of early OBD II vehicles without enhanced evaporative strategies still operating on the highways. These vehicles are contributing to higher levels of ambient emissions wherever they travel.

These studies were performed in an area that has had I/M testing for many years, as a result, the motoring public is well aware that vehicle maintenance is important in order to pass an emissions test. Motorist, therefore are more likely to maintain their vehicles especially when out of warranty. Since motorist in the study area are very likely to maintain their vehicles expectations that if this study were duplicated in a non-I/M venue the results would show much higher percentage of >1g/Qhr and >0.3g/Qhr vehicles than were identified here. This study provides valuable data regarding the ability of OBD II to identify, or not, evaporative issues with vehicles. What is very positive is that if the MIL is illuminated with an evaporative DTC it is broken and does have high emissions.

This study also indicates that many OBD II equipped vehicles are emitting at levels identifiable by RSD and verifiable using SHED testing. For whatever reasons there are high emitting OBD II vehicles the facts indicate there may be significant emissions coming from vehicles assumed to be very clean by federal and state agencies using statistical modeling. If this study is a good indication of real life experience, and it should be, modeling of OBD II vehicles without enhanced evaporative strategies should be weighted more than newer OBD II vehicles with enhanced evaporative monitoring. There appears a strong correlation between vehicle age and emissions and between non-enhanced evaporative strategies and newer OBD II equipped vehicles.