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DRAFT FOR REVIEW

TWG Air Quality Planning Technical Analysis-

Investigation of Diesel Inspection and Maintenance Program (I/M) in the DFW Area

TEXAS TRANSPORTATION INSTITUTE
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COLLEGE STATION, TEXAS

Prepared for the Texas Department of Transportation

August 2011

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Task 2.1 – FY 2011

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By

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

Overview

The purpose of this subtask is to provide the Texas Department of Transportation (TxDOT) with an overview of the Inspection/Maintenance (I/M) programs for heavy-duty diesel vehicles (HDDVs) with a view of possible implementation in the Dallas-Fort Worth (DFW) ozone (O_3) nonattainment (NA) area. To meet National Ambient Air Quality Standards (NAAQAS), state and local agencies in NA areas (including the DFW area) have been searching for feasible options, including I/M programs for diesel vehicles, to reduce emissions from all sources including mobile-source emissions.

Currently, I/M programs in Texas are limited to light-duty gasoline vehicles although diesel vehicles, especially, HDDVs, are one of the most significant contributors to emissions of oxides of nitrogen (NO_x), one of the main precursors of O_3. Studies have shown that a small percentage of "high emitters" in the HDDV fleet often contribute to the majority of the emissions.

The North Central Texas Council of Governments (NCTCOG) is interested in investigating the possibility of implementing an I/M program for HDDVs in the DFW NA area to identify and address high-emitting diesel vehicles. The findings of the investigation are presented in this report. In addition, a pilot testing plan to examine whether a diesel I/M program would be feasible and possible in the DFW area was developed and proposed.

This report consists of five chapters. This chapter (Chapter 1) provides an overview of the task. The remainder of this report describes the findings of diesel I/M programs, including I/M programs nationwide and in Texas (Chapter 2), and I/M testing methodologies and procedures (Chapter 3). This report also includes a proposed pilot testing plan for remote sensing devices (RSDs) and portable emissions measurement systems (PEMS), which will be performed in FY 2012 (Chapter 4). The final chapter (Chapter 5) presents a summary of the findings.

CHAPTER 2: I/M PROGRAMS

TTI researchers investigated I/M programs, focusing on diesel I/M programs. The findings are described in the following sections.

Overview of I/M Programs

Vehicle I/M programs help improve air quality by identifying high-emitting vehicles in need of repair and requiring them to be repaired as a prerequisite to vehicle registration within a given NA area.[1] Under the Clean Air Act as amended in 1990 (CAAA), certain ozone NA areas are required to adopt vehicle I/M programs as one of the mandatory control measures used to reach attainment.[2] The CAAA required the U.S. Environmental Protection Agency (EPA) to develop federally enforceable guidance, and, in response, the EPA published its I/M rule on November 5, 1992.[3] That rule established the minimum procedural and administrative requirements to be met by basic and enhanced I/M programs. In March 2006, the EPA announced the final rule with finalizing revisions – Code of Federal Regulations (CFR) Title 40 Part 51 (40 CFR 51).[4]

The first I/M program was implemented in New Jersey in 1974 and consisted of an annual idle test of 1968 and newer light-duty gasoline-powered vehicles conducted at a centralized facility even before the first I/M rule was established.[5] According to a NCTCOG investigation,[6] 34 U.S. states, including Texas, have implemented I/M programs.

Texas I/M Programs

Texas first established vehicle emissions testing programs on January 1, 1995, meeting the EPA's requirements for I/M programs.[7] The I/M program for gasoline-powered vehicles has been implemented in 15 counties in the DFW, Houston-Galveston-Brazoria (HGB), and El Paso NA areas, and in Travis and Williamson counties in the Austin-Round Rock area.[7] The I/M program requires the annual inspection of gasoline-powered vehicles 2–24 years old in the affected counties.[7] However, the I/M program is limited to gasoline-powered vehicles only. Diesel-powered vehicles and motorcycles are exempt from emissions testing.[8]

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[1] EPA. Inspection & Maintenance (I/M), http://www.epa.gov/otaq/im.htm, accessed June 2011.

[2] EPA. Regulatory Announcement: Final Rule for Amendments to Vehicle Inspection Maintenance Program Requirements, http://www.epa.gov/otaq/regs/im/420f06028.htm, EPA420-F-065-028, March 2006.

[3] EPA. IM Program Requirements; Final Rule, 40 CFR 51 (57FR52950), November 5, 1992.

[4] EPA. Amendments to Vehicle Inspection Maintenance Program Requirements to Address the 8-Hour National Ambient Air Quality Standard for Ozone, 40 CFR 51, FR Vol. 71, No. 67, 17705-17712, April 7, 2006.

[5] EPA. Guidance on Use of Remote Sensing for Evaluation of IM Program Performance, EPA-420-B-04-010, Jul 04.

[6] NCTCOG. Personal conversation/data transfer, June 2011.

[7] Texas Commission on Environmental Quality (TCEQ). Vehicle Inspection and Maintenance (I/M) Program, http://www.tceq.texas.gov/airquality/mobilesource/im.html, accessed 2011.

[8] TxDOT. Inspection Criteria for the Annual SAFETY Inspection, http://www.txdps.state.tx.us/vi/inspection/item_insp.asp, accessed 2011.

Diesel I/M Programs

Among the 34 states that implement I/M programs, 22 states have both gasoline and diesel I/M programs; 19 states have programs for light-duty diesel vehicles (LDDVs), 3 states have programs for medium-duty diesel vehicles (MDDVs), and 11 states have programs for HDDVs. Among the 22 states, some states have diesel I/M programs for all LDDVs, MDDVs, and HDDVs while some other states only test one or two types of vehicles. Currently, Texas does not have any diesel I/M programs.

For MDDVs, all three states use on-board diagnostics (OBD) testing. For LDDVs, most states (12 states) use solely OBD testing while others use opacity reading and/or other methodologies with or without OBD testing. Table 1 shows the states that have diesel I/M programs along with their testing methodologies. For HDDVs, most states (nine states) including California use opacity testing. New Jersey uses opacity testing or idle testing depending on the vehicle specifications while Illinois uses idling testing only. Oregon has a plan for HDDV OBD testing for 2013 or newer trucks. (The testing methodologies will be discussed in the I/M Testing Methodologies section.) TTI developed Table 1 using data provided by NCTCOG.6

Table 1: Diesel I/M Programs.

State	Testing Methodology		
	LDDV	MDDV	HDDV
Arizona	OBD	N/A*	Opacity
California	OBD	OBD for vehicles of GVWRs** less than14,000	Opacity
Colorado	Opacity	N/A*	Opacity
Connecticut	OBD or Loaded Mode Diesel Test	N/A*	Opacity
Illinois	N/A*	N/A*	Idle Exhaust
Maine	N/A*	N/A*	Opacity
Massachusetts	OBD for MY 1997 or newer vehicles	OBD for MY 2008 or newer vehicles	Opacity
Missouri	OBD	N/A*	N/A*
Nevada	Loaded Mode Diesel and Opacity	N/A*	N/A*
New Hampshire	OBD	N/A*	N/A*
New Jersey	OBD	N/A*	Opacity/Curbside Idle for vehicles of GVWRs** more than 18,000
New York	N/A*	N/A*	Opacity
North Carolina	OBD	N/A*	N/A*
Ohio	Opacity	N/A*	N/A*
Oregon	OBD, Idle and Opacity	N/A*	OBD for MY 2013 or newer vehicles
Rhode Island	OBD or Loaded Opacity	N/A*	N/A*
Tennessee	OBD	OBD for vehicles of GVWRs** equal to or less than10,000	N/A*
Utah	OBD	N/A*	Opacity
Vermont	OBD	N/A*	N/A*
Virginia	OBD	N/A*	N/A*
Washington	Opacity	N/A*	Opacity
Wisconsin	OBD	N/A*	N/A*

* N/A: Not Applicable for that type of vehicle.
** GVWR: Gross Vehicle Weight Rating (in pounds).
Data source: NCTCOG.6

CHAPTER 3: TESTING PROTOCOLS/METHODOLOGIES FOR I/M PROGRAMS

Currently, for diesel I/M programs, three types of testing methodologies are utilized: OBD testing, opacity testing, and idle testing. This chapter describes these three and other testing methodologies, which have been considered for I/M testing and/or screening of high-emitting vehicles, including a remote sensing (RS) testing methodology.

OBD Testing

The CAAA requires a computer-based (OBD) system to be built into all model year (MY) 1996 and newer LDVs (for both light-duty cars and trucks). OBD systems are designed to monitor the performance of major components of an engine including those responsible for controlling emissions.[9]

During an emissions inspection, the analyzer plugs into the diagnostic link connector, checks and downloads stored information from the emissions-related components to identify those not working properly. Given the robust nature of today's emissions control components of a vehicle, it is entirely possible for an individual component to malfunction without leading to an immediate increase in emissions at the tailpipe.[10] In such cases, other components (such as the catalyst) can temporarily compensate for the part that is broken or malfunctioning; however, these other components can only do double duty for so long before they, too, begin to malfunction.[10] An OBD test offers a short inspection time for the consumer and an accurate diagnosis of needed repairs.[11] Many states have already incorporated OBD checks into their I/M programs as mentioned in previous sections and shown in Table 1. (Texas uses OBD testing for the current I/M programs for 1996 and newer gasoline vehicles.[12]) It is a quick testing methodology, but, for heavy-duty (HD) vehicles (either gasoline or diesel vehicles), OBD systems will not be available until 2013, which is the reason why Oregon has only planned to use HD OBD for their diesel I/M program MY 2013 or newer.

Opacity Testing

Opacity Testing (or smoke testing) is a methodology to measure smoke density (as opacity readings) from a tailpipe while a vehicle idles. Using a smoke meter, the transparency or opacity of exhaust smoke from the tailpipe of a vehicle is measured. The more opacity, the more smoke

[9] EPA. On-Board Diagnostics (OBD), http://www.epa.gov/obd/, accessed 2011.

[10] EPA. On-Board Diagnostics (OBD): Frequent Questions, http://www.epa.gov/obd/questions.htm, accessed 2011.

[11] EPA. More States Are Using OBD for Vehicle Inspection and Maintenance Programs, http://www.epa.gov/obd/pubs/inspection.pdf, accessed 2011.

[12] TCEQ. Revision to the State Implementation Plan Mobile Source Strategies: Texas Inspection and Maintenance State Implementation Plan Revision, 2009-1613-SIP, November 18, 2010.

and particulate matter (PM) that are emitted. States conducting opacity tests follow the Society of Automotive Engineers (SAE) protocol J1667.[13]

SAE J1667 is designed for use on a stationary vehicle. After the engine is warmed-up, smoke opacity is measured at its maximum governed engine speed idling (i.e., full throttle idling). Based on the smoke density produced at full throttle idling, opacity readings (from 0% [no smoke] to 100% [smoke blocks entirely]) are recorded. For I/M testing, the opacity readings are to compare the results to criteria values for determining pass or fail. For each vehicle, test time is normally 20-to-30 minutes including installation time. The J1667 test is used by most states conducting opacity testing with the exception of a few states that conduct opacity testing while vehicles (LDVs) are driving on chassis dynamometers. An opacity test provides indirect PM concentration (as opacity readings) with actual tailpipe measurements using an opacity meter. Recently, TTI conducted a study including opacity testing of HDDVs, a correlation between opacity readings and PM levels were found but very limited correlation was observed between opacity levels and gaseous emissions such as NO_x.[14]

Idle Testing

Idle testing (or curbside idle/idle exhaust testing) measures pollutant emissions directly from tailpipes by emissions analyzers. For idle testing, there are two testing methodologies; single-speed and two-speed idle testing. For the single-speed idle testing, emissions testing is conducted at one engine speed, while the two-speed idle (TSI) testing is conducted at two different engine speeds; one at a low engine speed and the other at a high engine speed.

For example, in Illinois, HD trucks receive a single-speed idle test (also referred to as a "steady state" test).[15] In Texas, the El Paso I/M program areas use the TSI emissions inspection[16] for designated vehicles (1995 or older LDGVs) not originally equipped with the second generation OBD (OBDII).[17] More detailed information is available from TCEQ's "Specifications for Vehicle Exhaust Gas Analyzer Systems for Use in the Texas Vehicle Emissions Testing Program."[18]

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[13] SAE. Snap-Acceleration: Smoke Test Procedure for Heavy-Duty Diesel Powered Vehicles, February 1996.

[14] Zietsman, J., L. Yu, R. Farzaneh, D.-W. Lee, and J. Johnson, Characterization of Exhaust Emissions from Heavy-Duty Diesel Vehicles in the HGB Area, RMC6237 Technical Report. Draft, submitted to TxDOT in August 2011.

[15] Illinois EPA. Understanding Idle Tests and Gas Cap Tests, http://www.epa.state.il.us/air/vim/faq/types.html, accessed August 2011.

[16] Texas Department of Public Safety. FAQs: ASM/TSI Emissions Testing, http://www.txdps.state.tx.us/vi/Misc/faq/faq_asm.htm, accessed August 2011.

[17] Texas Department of Public Safety. Inspection Criteria for the Annual SAFETY Inspection, http://www.txdps.state.tx.us/vi/inspection/item_insp.asp, accessed August 2011.

[18] TCEQ. Specifications for Vehicle Exhaust Gas Analyzer Systems for Use in the Texas Vehicle Emissions Testing Program, December 31, 2010, http://www.tceq.state.tx.us/assets/public/implementation/air/ms/IM/txvehanlspecs.pdf.

During idling, exhaust emissions of a vehicle are measured by using emissions analyzers from the exhaust sample drawn through a tailpipe probe inserted into the tailpipe. When analyzers are ready and a vehicle is warmed-up, the testing normally takes less than 15 minutes.

ASM/Loaded Mode Diesel Testing

The Accelerated Simulation Mode (ASM) Test (or Loaded Mode Diesel Test) is an emissions testing methodology using a dynamometer, which measures emissions under simulated driving conditions. During the test, a vehicle runs at different speeds and different load conditions with or without any idle tests. While the vehicle runs at different test conditions, exhaust emissions are measured by using emissions analyzers from the exhaust sample drawn through a tailpipe probe. Based on a comparison of the applicable test standards and the measured emissions values, a pass or fail determination is made. More detailed information is available in the EPA's final technical guidance.[19]

In Connecticut, vehicle emissions for MY 1995 and older vehicles are measured using this loaded mode diesel testing.[20] Texas, in the DFW and Houston/Galveston area I/M programs use the ASM emissions inspection[21] for designated vehicles (1995 or older LDGVs) not originally equipped with an OBDII.[17] When analyzers, the dynamometer, and other necessary equipment are ready and a vehicle is warmed-up, the testing takes normally less than 15 minutes.

IM240 Testing

The IM240 test procedures were developed by the EPA for in-use LDVs in I/M programs. For an IM240, a vehicle follows a driving schedule on a chassis dynamometer. The driving schedule (shown in Figure 1) is short (240 seconds) and consists of a 1.96 mile (3.1 km) route with an average speed of 29.4 mile/h (47.3 km/h), and has a maximum speed of 56.7 mile/h (91.2 km/h).[22] More detailed information is available in EPA's IM240 & Evap Technical Guidance.[23]

[19] EPA. Acceleration Simulation Mode Test Procedures, EmissionStandards, Quality Control Requirements, and Equipment Specifications: Final Technical Guidance, EPA420B-04-011, July 2004, http://www.epa.gov/otaq/regs/im/420b04011.pdf, accessed August 2011.

[20] Connecticut Department of Motor Vehicles. Connecticut Emissions Program – General Information, http://www.ctemissions.com/gen-different.html, accessed August 2011.

[21] Texas Department of Public Safety. FAQs: ASM/TSI Emissions Testing, http://www.txdps.state.tx.us/vi/Misc/faq/faq_asm.htm, accessed August 2011.

[22] Dieselnet. Emission Test Cycles: Inspection & Maintenance Driving Cycle IM240, http://www.dieselnet.com/standards/cycles/im240.html, accessed August 2011.

[23] EPA. IM240 & Evap Technical Guidance, EPA420-R-00-007, April 2000.

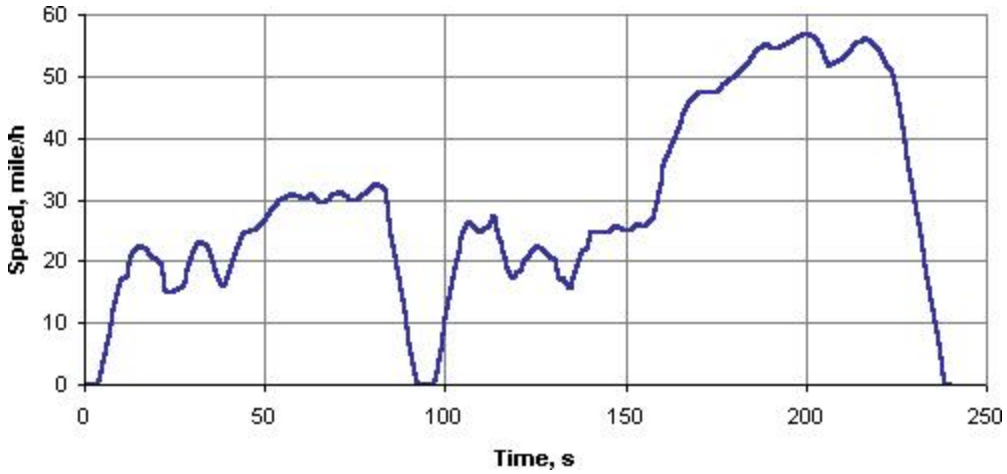

Figure 1: IM240 Driving Schedule.

Source: Dieselnet.[22]

Because it is not an easy task to follow the drive schedule, trained professional drivers are needed to conduct IM240 testing. Because of the complexity, only a few states use IM240 testing for vehicle inspection. For example, Washington D.C. provides IM240 inspection service as well as OBD and idle testing.[24] When analyzers, a dynamometer, and other necessary equipment are ready and a vehicle is warmed-up, the testing takes normally less than 15 minutes.

Remote Sensing Testing

RS testing is a way to measure pollutant levels in a vehicle's exhaust while the vehicle is traveling down the road.[25] Figure 2 shows how RS testing is performed with RS devices (RSDs). Commercial RSDs operate by continuously projecting a beam of infrared radiation across a roadway. As a vehicle passes through the beam, the device measures the ratio of pollutants to carbon dioxide (CO_2) in front of the vehicle and in the exhaust plume behind, and the RSD uses the "before" measurement as a base and calculates the vehicle's emissions rate by comparing the "behind" measurement to the expected ratio for ideal combustion.[25] Average speed and acceleration are also measured to help determine the operational mode of the vehicle, which helps determining when "off-cycle" operation is occurring (for example, aggressive acceleration, when vehicles can be expected to have higher than normal emissions).[26]

[24] Washington D.C. Department of Motor Vehicles. Vehicle Inspections - Clean Air, http://dmv.dc.gov/serv/inspection/inspection_main.shtm, accessed August 2011.

[25] EPA. Remote Sensing: A Supplemental Tool for Vehicle Emission Control, EPA420-F-92-017, 1992.

[26] ERG. Estimating Benefits and Costs of Improvement Strategies for the California I/M Program: Implementation Options for Using RSD; Report Version 9 (final), March 2, 2008.

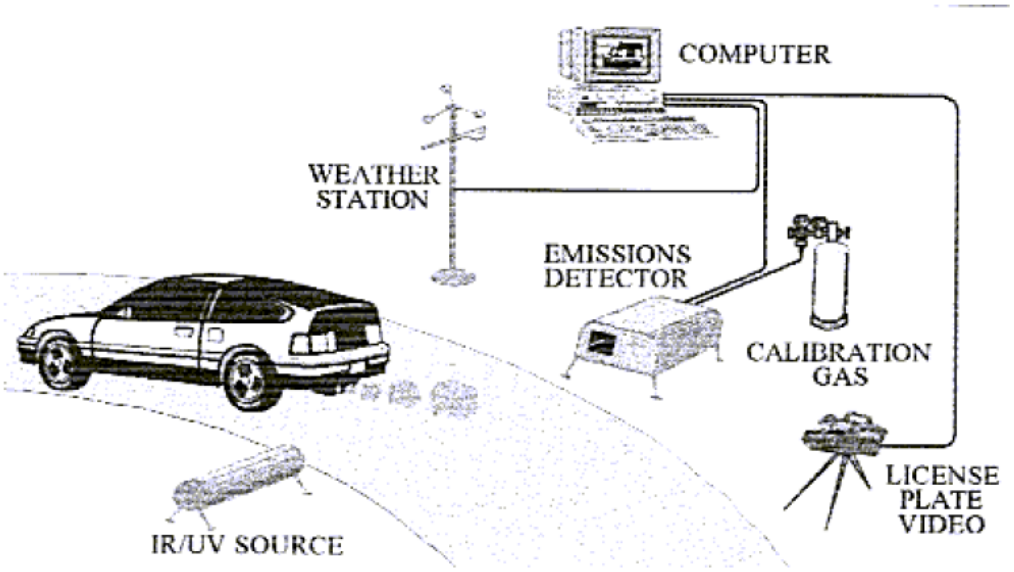

Figure 2: RSD Operational Diagram.

Source: EPA.5

During the literature review, it was found that RS testing was recommended for screening. For example, the Committee on Vehicle Emission Inspection and Maintenance Programs of TRB stated that RS can be a useful screening tool to identify vehicles likely to pass or fail conventional I/M program tests.[27] Additionally, RSDs were recommended by the EPA as a part of enhanced I/M programs (on-road testing) but not for replacement of the I/M programs.[25] Clean screening is the term used to describe methods that states can use to excuse cars from a scheduled I/M emissions test.[28] Most of these findings have been for passenger cars and light truck emissions. The effectiveness of RS varies among cars of different model years, so the overall effect will depend on the calendar year of interest and the mix of cars on the road.[28]

When RSDs and other necessary equipment are ready, RS testing for each vehicle takes as little as less than a second. However, such quick testing results can produce uncertainty about the quantitative significance of a measurement made over only about ½ second during which there is no detailed knowledge about the driving mode of the vehicle.[29] In Texas, the Department of Public Safety (DPS) uses RS to identify high-emitting vehicles operating in the DFW, HGB, and El Paso program areas.[12]

[27] TRB. Evaluating Vehicle Emissions Inspection and Maintenance Programs. National Academies Press, p. 10, 2001. (ISBN: 0-309-56537-5).

[28] EPA. Clean Screening in Inspection and Maintenance Programs, EPA-F-98-023, May 1998.

[29] Slott, R. Remote Sensing Measurement of Real World Vehicle High-Exhaust Emitters: Interim Report, CRC Project no. E-23, April 2002.

Portable Emissions Measurement System (PEMS) Testing

PEMS testing is an in-use emissions testing methodology. PEMS provides complete and very accurate real-time monitoring of the pollutants emitted by the engines (hydrocarbon [HC], carbon monoxide [CO], CO_2, and NO_x), together with the associated engine, vehicle, and ambient parameters.[30] The EPA regulation, 40 CFR 1065, describes PEMS testing procedure for gaseous sampling including NO_x, CO, HC, CO_2 in a high level of detail, and specifies the instruments required for these tests.

PEMS testing requires installation of a PEMS and other equipment including an exhaust flow meter, which measures exhaust characteristics such as exhaust volume and temperature; vehicle interface, which provides engine parameters such as engine speed (rpm); and sampling lines that deliver exhaust samples to the PEMS. The time required for installation and preparation, including PEMS warm-up time, is approximately 1-to-2 hours. Then, the PEMS unit provides second-by-second emissions results along with other parameters including vehicle and engine speeds. To test another vehicle, however, the PEMS unit and other equipment must be dismantled from the previously-tested vehicle and installed on the new vehicle.

PM Filter Sampling

PM filter sampling will be used to validate opacity testing, which is proposed for the pilot testing plan. (Details for the pilot testing plan are described in Chapter 4.) The PM filter sampling is the current federal reference method for PM measurements. Exhaust PM transferred through a heated line to a dilution tunnel from a probe in the exhaust is collected on PM filters. The collected mass is determined by the weight difference of the filters before and after the PM sample collection. (More detailed information is available in the EPA rule, 40 CFR 1065.)

Dekati Mass Monitor (DMM) Sampling

This test methodology is used to supplement the filter method and to develop correlations between mass monitoring and filter sampling. In this methodology, PM mass is continuously monitored. The exhaust particles entering into a DMM are charged, and the charged particles are collected on charge measurement devices. Then the measured charges are converted into PM mass. (More detailed information of DMM and the measurement methodology is available in the literature.[14])

PM PEMS Sampling

In this methodology, PM mass is also continuously monitored by a PM PEMS (Axion manufactured by Clean Air Technologies International, Inc). The exhaust particles entering into an Axion are detected by laser light scattering. Then, the scattered light measurements are converted to PM mass using the Axion internal software calculations. (More detailed information of DMM and the measurement methodology is available in the literature.[14])

[30] European Commission Joint Research Center. In-Use Emission Testing and PEMS, http://ies.jrc.ec.europa.eu/eu-pems, accessed August 2011.

Table 2 lists all the methodologies described. The selected testing methodology for the purpose of this study must be able to identify high emitters of diesel NO_x emissions in the DFW area. Many high-emitting vehicles need to be tested without any special vehicle recruitment. As shown in Table 2, only RS testing can accommodate so many vehicles without any special test vehicle recruitment. However, the RS testing provides indirect emissions results. To validate the testing results, PEMS testing, which can verify the results accurately during the screening field tests, is recommended. In addition, opacity testing, which most other states that implement diesel I/M programs for HDDVs use, is also proposed. To validate the indirect testing results of opacity testing, PM filters and instruments will be used.

Table 2: Average Fuel Economy and Emissions Comparison Results for All Selected Vehicles.

	Testing Time*	Tailpipe Measurement	Actual Emissions Measurements	Cost
OBD Testing	Fast	No	No	Low
Opacity Testing	Slow	Yes	Yes, but indirect values for limited conditions	Low
Idle Testing	Medium	Yes	Yes, but for limited conditions	Medium
ASM Testing	Medium	Yes	Yes, but for limited conditions	High
IM240 Testing	Medium	Yes	Yes	High
RS Testing	Very fast	Yes	Yes, but indirect values	High
PEMS Testing	Very slow	Yes	Yes	High
PM Filter	Very slow	Yes	Yes	Low
DMM	Medium	Yes	Yes, but indirect values	Medium
PM PEMS	Slow	Yes	Yes, but indirect values	Medium

* Testing time (including warm-up time and equipment installation) of 1 minute or less is designated as very fast, 1 – 5 minutes is designated as fast, 5 – 15 minutes is designated as medium, 15 – 30 minutes is designated as slow, and more than 30 minutes is designated as very slow.

CHAPTER 4: PILOT TESTING PLAN PROPOSED FOR HDDV I/M PROGRAM

Introduction

TTI researchers propose a pilot testing plan that will assist TxDOT and NCTCOG in deciding how to proceed with a more comprehensive deployment of a HDDV I/M program. The pilot program will involve the screening of HDDVs using both an RSD, and an opacity meter. It will also involve the testing of vehicles in motion using PEMS and during idling conditions using PEMS, DMM, and filter sampling. All the collected data will be used to develop correlations between the screening and the more sophisticated emissions testing. The correlation will indicate the accuracy and usefulness of the screening methods. The various testing methods will be also evaluated to determine an appropriate approach for an HDDV I/M program.

An RSD and its related equipment will be set-up at the selected test location to test as many HDDVs as possible. The RSD will measure gaseous opacity and approximate levels of gaseous emissions from the HDDVs as they pass the RSD. Additionally, a PEMS will be installed on 10 selected HDDVs. The PEMS-equipped HDDVs will also pass through the RSD following pre-developed driving conditions (such as cruise at 10, 20, and 30 mph and full throttle acceleration after stopping before the RSD). The on-board PEMS will simultaneously capture vehicle operating information and pollutant emissions (NO_x, CO, THC, and CO_2).

At the selected test location, an opacity meter, PEMS, PM samplers/instruments, and the associated equipment including a dilution tunnel and pumps, will be set-up for idling testing. With the selected HDDVs, emissions testing will be conducted at different idle conditions according to the J1667 procedure.

The proposed budget for the pilot testing which includes 10 days of RSD testing, and using 10 test HDDVs (1 HDDV per testing day) is approximately $150,000. This includes, preparation, logistics, testing, data processing and analyses, and report writing.

Potential Test Locations

Preliminary investigations of possible test locations were conducted. Three locations are proposed for consideration:

- Dallas Intermodal Terminal (DIT) at I-45 South bound (Exit 272) in Dallas County;
- Ferris Weigh Station (FWS) on I-45 North bound in Dallas County; and
- New Waverly Weigh Station (NWWS) on I-45 North bound in Walker County.

The DIT and FWS are located in Dallas County (at the same exit on I-45 – DIT at southbound and FWS at north bound exits), so that all HDDVs passing these locations would be target vehicles. The DIT facility has a shed area. All HDDVs (both long-haul and short-haul HDDVs) pass the shed area. (Figure 3 shows pictures of the shed area.) Currently, DIT is considered the best location for RS testing, but permission from DIT is required for testing because it is private property. However, FWS does not have any shed areas. (Figure 4 shows a picture of FWS.)

(a) (b)

Figure 3: Pictures of DIT; (a) Shed Area and (b) Shed Area Close-Up.

Figure 4: Picture of a FWS Weighing Lane.

The NWWS is located about 150 miles from Dallas. All HDDVs passing this station may not be traveling to the DFW area. The NWWS has a shed area with a 16 foot height limit as shown in Figure 5 (c). (Figure 5 shows the NWWS.) The shed area is better for an RSD set-up than the weighing lane shown in Figure 3(a), but not all of the vehicles are pulled into the shed area.

(a)

(b)

(c)

Figure 5: Pictures of NWWS; (a) Weighing Lane (b) Shed Area, and (c) Shed Area Close-Up.

Detailed Test Procedures

RS Testing

The main purpose of the proposed RS testing is to screen HDDVs to determine the emissions profile of HDDVs passing the selected location and to identify possible high emitters that need to be tested in more detail. A RSD and other equipment will be installed at a test location to measure (mainly) HDDV NO_x, HC, CO, and CO_2 emissions. Detailed test protocols will be developed to conduct the RS screening and testing. The test protocols will include, but are not limited to:

- A test location (in the DFW area) where as many HDDVs as possible can be tested during a range of operating modes;
- Test vehicle driving characteristics as test vehicles pass through RSDs;
- Identification of long-haul HDDVs which are more likely well-maintained and probably not registered in the DFW area;
- Identification of short-haul HDDVs which more likely will not be well-maintained and are probably registered in the DFW area;
- Test duration to obtain a large enough sample to permit valid conclusions;
- Comparison of results by age of trucks; and
- Validation of RS test data with PEMS and other instruments.

Opacity Testing

Similar to the RS testing, the main purpose of the proposed opacity testing is to screen HDDVs to identify high emitters. An opacity meter and associated equipment will be installed on a sample of HDDVs. Each HDDV will follow the J1667 testing procedures. Additional idle tests with different idle conditions (such as low and medium engine speed) will also be taken. The opacity testing data will be compared with other PM measurement data to validate the opacity data. Detailed test protocols will be developed to conduct the opacity testing. The test protocol will cover aspects such as:

- Conforming to J1667 test procedures;
- A range of idle conditions;
- Test vehicles for opacity testing;
- Test set-ups including PM measurement systems;
- The number of tests for each vehicle at each test condition;
- Comparison of PM results from different measurement methodologies;
- Comparison of PM results with NO_x results; and
- Validation of opacity test data with other PM data.

PEMS Testing

The main purpose of the proposed PEMS testing is to validate RS testing results and to determine whether PEMS testing should form a major part of an HDDV I/M program. PEMS

and associated equipment will be installed on a sample of HDDVs. Each HDDV will pass a RSD during different driving conditions. The PEMS data will be compared with the RS data to validate the RS data. PEMS testing will also be performed during the idling testing phase of the pilot project. The test protocol will include, but will not be limited to:

- Test vehicles for PEMS testing;
- Test load (weight of tractor and trailer);
- Driving conditions when passing the RSD;
- Frequency of the vehicle for PEMS testing to pass the RSD;
- Idling rates;
- Test duration; and
- Methods to compare PEMS data with RS data for validation/adjustment of the RS data.

CHAPTER 5: CONCLUSIONS

TTI researchers performed a literature review of published and unpublished materials including websites and databases of the EPA, the California Air Resources Board, the Texas Commission on Environmental Quality, and state agencies using I/M programs. TTI researchers also contacted staff at NCTCOG to obtain information on diesel I/M programs. The research team investigated I/M programs and test protocols related to I/M programs, A pilot test program was also proposed that can lay the foundation for the deployment of a full-scale HDDV I/M program. The key findings of the study are summarized in the following.

- Compared to LDGVs for which an I/M program has been implemented in Texas, diesel vehicles, especially HDDVs, can be more significant contributors per vehicle to emissions of NO_x.
- Among the 34 states that implemented I/M programs, 22 states have both gasoline and diesel I/M programs; 19 states have programs for LDDVs, 3 states have programs for MDDVs, and 11 states have programs for HDDVs.
- For HDDV I/M programs, states use opacity testing and idle testing. Oregon plans to use OBD testing for 2013 or newer HDDVs. It is expected that this trend will be followed by other states.
- HDDV I/M testing can be conducted using a broad range of equipment such as RSDs, opacity meters, PEMS, filter samples, and PM mass monitors. These tests can be conducted during idling and actual driving and can be divided between screening and actual testing.
- TTI investigated several emissions test methodologies for I/M and other testing, and decided to use RSDs for the pilot testing to maximize the testing data because RS testing time for each vehicle usually takes less than a second.
- A pilot testing project is proposed to evaluate the effectiveness and accuracy of RSDs as a screening device and to test the applicability of other testing equipment such as opacity meters, PEMS, and PM samplers. The pilot study will result in a proposed methodology for an HDDV I/M program.