Attachment D: 2010 Quality Control Report
Audits of OBD Test Equipment

40 CFR section 51.366(c)

Massachusetts Vehicle Check
Inspection and Maintenance Program

Attachment D: 2010 Quality Control Report

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1.0 Background

1.1 Types of Emissions Tests in Massachusetts

Since October 1, 2008, Massachusetts has used the OBD emissions test for light- and medium-duty vehicles equipped with OBD systems. This change coincided with a change in I&M contractors, and all emissions test workstations were replaced with updated equipment.

In addition to OBD emissions tests, on October 1, 2009, opacity testing resumed for 1984 and newer diesel-fueled vehicles with a Gross Vehicle Weight Rating (GVWR) over 10,000 pounds that are not subject to an OBD test.

1.2 Overview of Test Equipment Audits and Self Checks

The Massachusetts Vehicle Check program uses two methods to ensure that the emissions test equipment is operating properly:

1. The workstations have been designed to run daily "self-checks", so that equipment with significant issues is identified (and repaired) as quickly as possible, and
2. RMV field inspectors audit equipment performance in the field.

Every 24 hours, the workstation is programmed to require the inspector to perform equipment checks that ensure the functionality of the OBD scan tool, printer, barcode scanner, and, if equipped, diesel opacity meter. These self checks include:

- The OBD scan tool performs a daily "loopback" check that tests the continuity of the OBD scan tool cable and pins in the Diagnostic Link Connector (DLC). Broken cables and damaged DLC pins are the most common reasons for the OBD scan tool to fail to communicate with a vehicle. In addition, the inspector is required to perform the loopback check following any OBD test that results in a communication failure to determine if a problem with the OBD cable or DLC pins was the cause of the failure. Whenever a loopback test fails, the workstation is locked out from performing OBD tests until a loopback check can be passed.
- The printer/barcode scanner check begins by the workstation printing sample 1D and 2D barcodes and sample Vehicle Inspection Report (VIR) text. The inspector examines the quality of the printed sample and records a failure for the printer/barcode scanner check if the text is not legible. If the print quality is good, the inspector is then prompted to scan the 1D and 2D barcodes. If the workstation cannot read the barcodes, it fails the check. This failure to read the barcodes can be caused by a faulty barcode scanner or poor print quality. If the printer/barcode scanner check fails, the workstation is locked out from performing ALL inspections until it can pass the check.
- For workstations equipped with diesel opacity meters, the opacity meters perform three daily self-checks: electronic zero and span; accuracy at 37.5% opacity by extinguishing 3 of 8 light pulses; and current draw of the sample fan. All three checks have tolerances which must be met to pass. If any of the three checks fails,

the workstation is locked out from performing diesel opacity tests until all three checks pass.

2.0 Procedure for OBD Test Equipment Audits

Sierra Research (Sierra) of Sacramento, CA developed general equipment audit guidelines for EPA for ASM-type equipment used in transient test I&M programs[1]. This document is the most applicable audit guidance for Massachusetts' decentralized OBD test program. The guidelines include auditing procedures for OBD test equipment, and MassDEP's OBD audit procedures were developed to be consistent with EPA's guidance. The three OBD audit parts are listed in Table 1.

Table 1: Audit Parts in the Massachusetts OBD Test Equipment Audit

Audit Part	Description	Required by EPA's Audit Guidance?
Communications Check	Automated check of the OBD test equipment's ability to communicate with the OBD vehicle simulator.	√
Accuracy Check	Accuracy check of the OBD test equipment's ability to retrieve specific diagnostic trouble codes (DTCs), readiness monitor status, and other data. The Accuracy Check includes a functional and accuracy check of the OBD test equipment's RPM pickup at 5000 RPM.	√ Modified
Visual Cable and Connector Check	Visual check of the cables and connector condition.	√

In 2009, MassDEP revised its OBD test equipment audit procedures by modifying the RPM portion of the accuracy check, and by adding to the items to be checked during the accuracy check. The RPM check was modified to test only one RPM setting (5,000 RPM) instead of the two RPMs recommended in EPA's audit guidance (700 and 2500), and to require that workstations must read exactly 5,000 RPM instead of within the range of ± 3% that was recommended in EPA's guidance. The results of MassDEP's prior OBD auditing experience supported the Agency's decision to simplify the OBD RPM audit (and to deviate from EPA's recommendations on this point). In auditing OBD equipment from 2002 through 2008, MassDEP found that the RPM reading always exactly matched the standard as long as the OBD vehicle simulator communicated with the workstation OBD test equipment.

[1] "U.S. EPA Steady State and Transient Testing Equipment Audit Guidance," July 2001

For the accuracy check, Massachusetts uses custom-built OBD vehicle simulators to generate signals for the OBD emissions testing equipment to read. There are six different configurations for the OBD vehicle simulators, covering six different OBD communication protocols: CAN (11 bit), CAN (29 bit), KWP (ISO 14230-4), ISO (ISO9141), VPW and PWM. The items listed in Table 2 are included in the OBD test equipment audit accuracy check.

Table 2: Items Included in the Accuracy Check

Item	Required by EPA's Audit Guidance?
OBDII RPM	√
MIL status	√
Misfire monitor status	√
Fuel System monitor status	√
Comprehensive Components monitor status	√
Catalyst monitor status	√
Heated Catalyst monitor status	√
Evaporative System monitor status	√
Secondary Air monitor status	√
A/C System monitor status	√
O2 Sensor monitor status	√
O2 Sensor Heater monitor status	√
EGR monitor status	√
DTC 1	√
DTC 2	√
DTC 3	√
DTC 4	√
DTC 5	√
DTC 6	√
Communication Protocol	
PCM Module ID 1	
PID Count 1	
PID $1C Response	
OBD VIN	

3.0 Workstation Selection for OBD Equipment Audits

The OBD equipment audits are conducted as one component of routine station site visits performed by RMV field investigators. Workstations are not selected to receive OBD audits based on data analysis or other information that may indicate the equipment may be broken. However, the workstations may be selected for an audit based on consumer complaints or data analysis that indicates the inspector(s) may be conducting improper inspections. Other methods of selecting the workstations to audit may include, but are not limited to, the length of time since the last audit, a high volume of inspections and the location of the station (to minimize field investigators' travel distance). Workstations may also be selected for follow-up audits following a previous audit failure.

4.0 OBD Test Equipment Audits

4.1 Number of Stations, Workstations, and OBD Test Equipment Audits

> 40 CFR 51.366 (c) Quality control report. …Basic statistics on the quality control program for January through December of the previous year, including:
>
> (1) The number of emission testing sites and lanes in use in the program;
>
> (2) The number of equipment audits by station and lane; . . .

In 2010, 1,586 stations and 1,646 workstations (lanes) conducted emissions inspections throughout the period. A station or workstation must have conducted at least one emissions inspection in each month in 2010 to be counted as "testing throughout the period." A total of 1,770 stations and 1,854 workstations conducted at least one emissions test at some time during 2010.

Thirty-one RMV field investigators performed a total of 2,131 OBD test equipment audits in 2010, which covered 1,156 different workstations (lanes) and 1,128 different inspection stations. 639 workstations were audited more than once.

4.2 OBD Test Equipment Audit Results

Table 3 presents a breakdown of the results of the Workstation OBD test equipment audits conducted in 2010, including individual audit parts and overall audit results. To pass the overall audit, the workstation cannot fail any individual audit part.

Table 3: OBD Test Equipment Audit Results

	2010 Audit Results			
Audit Part	**Pass**	**Fail**	**Tested**	**Failure Rate**
Functional Checks				
Communications Check	2,127	4	2,131	0.2%
Accuracy Check, (Including RPM)	2,125	2	2,127[2]	0.1%
Audits Failing One or More Functional Checks	2,125	6	2,131	0.3%
Visual Cable and Connector Check	2,100	27	2,127[3]	1.3%
Overall Audit Results (Audits that failed one or more audit parts)	2,098	33	2,131	1.5%

A total of six workstations failed a functional check of the workstation's performance. Four workstations failed the communications check and two workstations failed the accuracy check. The two workstations that failed the accuracy check failed to report the OBD VIN and returned PID $1C responses that indicated that the workstations did not recognize the signal from the OBD vehicle simulator as an OBD compliant vehicle. The two failing items, PID $1C response and the OBD VIN, are not required by the EPA audit guidance. The audit was repeated for each of these workstations. Both workstations passed their second accuracy check indicating there was a communication problem between the OBD simulator and workstations on the initial audits that could not be reproduced. As a result, no service tickets were opened for these two workstations. MassDEP and the Network Contractor continue to review accuracy check audit results.

Service tickets were opened, and service provided, for all four workstations with communication failures.

Twenty-seven workstation audits failed the visual cable and connector check. All twenty-seven of these workstation audits passed for both communication and accuracy indicating that, while the visual condition of the equipment was questionable, it still performed adequately. Service tickets were opened for about half (14) of the twenty-seven failures on the visual cable and connector check. For the majority of the remaining visual failures, the audit comment in the data base indicated that the problem may not have been severe enough to merit service at the time of the audit or that service was not necessary. Examples of audit comments include: "station has a new connector [to replace

[2] The accuracy check could not be done for the four workstation audits that had failed for communication.
[3] Due to the functionality of the current audit software, the visual cable and connector check results were not recorded in the database for the four workstation audits that failed for communication.

the worn one]" "lock clip on blue OBD connector broke but still holds" and "OBD cable wire starting to wear." These types of comments are helpful to the auditors for subsequent visits. In the meantime, daily loopback checks of the OBD interface and cable should identify when the components wear to the point of becoming unreliable.

4.3 OBD Test Equipment Audit Results for Stations

> 40 CFR 51.366 (c) Quality control report. …Basic statistics on the quality control program for January through December of the previous year, including: . . .
>
> (3) The number and percentage of stations that have failed equipment audits; and
>
> (4) Number and percentage of stations and lanes shut down as a result of equipment audits.

Most inspection stations have only one workstation in the Massachusetts I&M program.

Twenty-nine workstations at twenty-nine stations failed at least one OBD audit in 2010. Four of these stations failed two audits.

In 2010, six workstations at six stations failed OBD functional checks. These six failures represent 0.5% (6/1,156) of all audited workstations (lanes) and 0.5% (6/1,128) of all audited inspection stations. The six failures were equivalent to 0.4% of all 1,586 stations that conducted emissions inspections throughout the year and 0.4% of all 1,646 workstations that conducted emissions inspections throughout the year.

Twenty-nine workstations at twenty-nine stations failed OBD functional checks or the visual cable or connector check. Four of these stations failed a second audit during 2010. These twenty-nine failures represent 2.5% (29/1,156) of all audited workstations (lanes) and 2.6% (29/1,128) of all audited inspection stations. The twenty-nine failures were equivalent to 1.8% of all 1,586 stations that conducted emissions inspections throughout the year and 1.8% of all 1,646 workstations that conducted emissions inspections throughout the year.

No stations or workstations were shut down as a result of the OBD equipment audits.

4.4 Editing of Audit Records for Analysis

There are several reasons that audit records in the database should be excluded from analysis. The audit data is carefully reviewed and records are excluded when appropriate. The acceptable reasons for excluding records from the analysis are:

- there is more than one audit record for a workstation on a given day;

- the field investigator's audit comment indicates removing the record is appropriate; and
- the record is a duplicate or near-duplicate record created due to software or audit procedure anomalies.

For any given day, only one audit of a workstation is included in the data analysis, because additional audits are usually performed to troubleshoot equipment upon an audit failure. When audits fail, it is common to complete one or more additional audits in order to confirm proper operation of the audit equipment or to isolate the source of the failure. The first audit is normally included in the analysis, unless the daily OBD loopback check is overdue (i.e. has not been conducted within 24 hours of the audit.) When the OBD loopback check is overdue, the station cannot perform an OBD test until a successful loopback check is completed. Usually when the OBD check is overdue, a loopback check is completed and the results of the audit that is conducted AFTER the successful loopback check are included in the analysis. In 2010, two workstation audits, conducted in different months at a single workstation, failed for communication when the workstation had not passed its loopback check for many months. The failing results for these two audits were excluded from the analysis, since the loopback check failures caused the workstation to be locked out from performing OBD tests. The inspection station, a bus company, did not conduct any OBD inspections in 2010. This station's repeated audit failures of its dormant OBD equipment lead the RMV to re-evaluate its policies. Stations are now required to keep all components of their workstations fully functional, even if the station reports it never uses some of its workstation components.

Field investigator comments in the audit database may indicate that a record should be excluded. For example the field investigator might indicate that he or she is correcting the results on the prior audit record. In addition, the absence of any comment, combined with one or more failures to communicate, typically indicates that the audit menus on the workstation were accidentally opened, creating a record when no audit was conducted.

In July 2010, the audit menus were modified to provide the choice of aborting the audit. This change allows investigators to exit the menu without recording a failing communication result. For the 2010 data, the extra records that were created due to problems aborting audits were removed from the analysis.

In 2010, the process for updating the database with records from the workstation occasionally created duplicate audit records with slightly different database time stamps. The contractor identified two causes for this issue: one has been corrected and the second software correction is planned for 2011. These duplicates were removed from the data analysis.

Applying the three criteria above lead to the exclusion of 108 audit records (from the total of 2,266 audit records). These excluded records were associated with ninety audits that were included in the data analysis. An additional twenty-seven records, associated with nineteen site visits, were excluded because they appeared to have been created

unintentionally by inadvertently opening the OBD audit menu, and had no associated audit records in the database.

5.0 Summary: OBD Equipment Audit Results Compared to Prior Year

The following table compares the audit failure rates between the audit pilot program in 2009 and the scaled up audit program in 2010. Though the failure rate for functional checks decreased, the notable increase in failures for the visual cable and connector check resulted in an increase in the overall failure rate for the OBD equipment audits.

Though it is possible that the increased failure rate for the visual cable and connector check is due to aging equipment at stations, it is more likely to be caused by a shift in the failure criteria for this component. After the conclusion of the 2009 audit pilot program, the limited number of field investigators who participated in the pilot program shared their experiences with the rest of the RMV staff. Training sessions with all RMV field staff in 2010 lead to more stringent criteria for passing the visual audits.

Table 4: OBD Test Equipment Audit Summary 2009 through 2010[4]

Audit Part	**2009 Failure Rate**	**2010 Failure Rate**
Functional Checks		
Communications Check	0.0%	0.2%
Accuracy Check, (Including RPM)	0.7%	0.1%
Percentage of Audits Failing One or More Functional Checks	0.7%	0.3%
Visual Cable and Connector Check	0.2%	1.3%
Overall Audit Failure Rate (percentage of audits that failed one or more audit parts)	0.9%	1.5%

[4] For audits from 2004 through 2008, the failure rate for OBD functional checks was 1.1% or less. The functional check during this period included visual failures when "the OBD cable was damaged to the point of being unusable or unsafe." No other visual checks of the cable or connector were conducted. The functional failure rate continues to maintain the improvements achieved over the 5% OBDII audit failure rate in 2003.