Attachment D: 2009 Quality Control Report
Pilot Audits of OBD Test Equipment

40 CFR section 51.366(c)

Massachusetts Vehicle Check
Inspection and Maintenance Program

Attachment D: 2009 Quality Control Report

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1.0 Introduction

In 2009, Massachusetts conducted pilot audits of the OBD emissions test equipment used to conduct vehicle inspections in the Commonwealth.

1.1 Background: Emissions Tests Administered in Massachusetts

Massachusetts began implementation of enhanced emissions testing October 1, 1999. This included transient and two-speed idle (TSI) tailpipe testing, and gas cap testing using a decentralized network of private inspection stations. Following a pilot test period, Massachusetts began using the Onboard Diagnostic (OBD) emissions test to pass and fail vehicles in June, 2004.

Effective October 1, 2008, Massachusetts discontinued tailpipe and gas cap emissions testing. Since October 1, 2008, the program 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. The new OBD test equipment was designed to include a series of daily self-checks, which helps to ensure that the equipment delivers accurate tests, and provides early warnings of issues.

1.2 Questions to Address in Pilot OBD Test Equipment Audits

Massachusetts began auditing emissions test equipment in November, 2001. These audits were conducted by a contractor that was separate from the contractor hired to administer the inspection program, with oversight by MassDEP. With the discontinuation of tailpipe and gas cap testing, EPA only requires auditing of the OBD test equipment.

Since the OBD auditing equipment is easily transportable, in 2009 Massachusetts conducted a pilot of OBD test equipment auditing to determine whether these equipment audits could be conducted by Registry of Motor Vehicle (RMV) field investigators as one part of their routine investigations and station visits. The audits conducted in 2009 were performed by RMV field staff, with training and technical support by MassDEP.

The pilot for OBD test equipment audits was designed to address the following questions:

- Is the Massachusetts OBD test equipment operating correctly?
- Is the auditing equipment adequate for OBD test equipment audits?
- Are the auditing software and the audit database performing as expected?
- Can the audit be incorporated into routine RMV investigations and site visits?
- Based on experience during the pilot, are modifications needed to the auditing procedures, equipment, software or database?

2.0 Procedure for OBD Test Equipment Audits

MassDEP developed its original equipment audit procedures based on recommendations from its consultant, Sierra Research (Sierra) of Sacramento, CA, and audit contractor, SGS TESTCOM, Inc. (TESTCOM) of Ballston Spa, New York. Sierra developed general equipment audit guidelines for EPA for ASM-type equipment used in transient test I&M programs[1]. The guidelines included auditing procedures for OBD test equipment, and MassDEP's OBD audit procedures were developed to be consistent with EPA's guidance. The four OBD audit parts are listed in Table 1.

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

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

In 2009, MassDEP revised its OBD test equipment audit procedures by modifying the RPM check, and by adding 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 20008, MassDEP found that the RPM reading always exactly matched the standard as long as the OBD auditing equipment communicated with the OBD testing equipment.

For the accuracy check, Massachusetts uses custom-built auditing equipment to generate signals for the OBD emissions testing equipment to read. The items listed in Table 2 are included in the OBD test equipment audit accuracy check.

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

Table 2: Items Included in the Accuracy Check

Item	Part of EPA's Audit Guidance?
OBDII RPM	√
MIL status	√
Misfire monitor status	√
Fuel System monitor status	√
Component 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 "PCM VIN"	

3.0 Results of the Pilot OBD Test Equipment Audits

In 2009, the pilot OBD test equipment audit program:

1. evaluated whether the Massachusetts OBD test equipment was operating correctly;
2. tested new auditing hardware;
3. tested the new auditing software and auditing database;
4. tested the feasibility of incorporating the audit into other RMV investigations and site visits; and
5. determined what modifications are needed to the auditing procedures, equipment, software and database to support a full-scale auditing program.

3.1 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 2009, 1,383 stations and 1,418 workstations (lanes) conducted emissions inspections throughout the period. A total of 1,745 stations and 1,801 workstations conducted emissions tests at some time during the year.

Eighteen RMV field investigators performed a total of 536 test equipment audits in 2009, which covered 526 different workstations (lanes) and 509 different inspection stations. Eleven stations were audited two times and 498 stations were audited one time. One of the stations that was audited twice had four workstations. Two of the four workstations were included in each audit. Thus, only 10 workstations were audited two times. 516 workstations were audited one time.

3.2 OBD Test Equipment Performance

Table 3 presents a breakdown of the results of the OBD test equipment audits conducted in 2009, 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

Audit Part	2009 Audit Results (Number of Audits)			
	Pass	**Fail**	**Tested**	**Failure Rate**
Visual Cable and Connector Check	535	1	536	0.2%
Communications Check	536	0	536	0.0%
RPM Pickup Check[2]	534	2	536	0.4%
Accuracy Check	532	4	536	0.7%
Number of audits that failed one or more audit parts	531	5	536	0.9%

One workstation failed because of the condition of the cable and connector. Four other workstations failed to recognize the signal from the audit equipment as an OBDII compliant device on the first audit.

The one workstation that failed its visual cable and connector checks passed all other items.[3] When a field investigator identifies problems with the cable or connector, station personnel are consulted regarding the condition of the test equipment and encouraged to open a service ticket, if appropriate.

All four workstations that failed the accuracy check failed in a manner that indicated that the workstation did not identify the signal from the audit equipment as an OBDII compliant device. As part of the pilot, the audit was repeated for each of these workstations. All four workstations passed their second accuracy and RPM checks. As a result, no service tickets were opened for these four workstations. MassDEP and the Network Contractor are reviewing these audit results.

As expected, the two workstations that failed the RPM pickup check also failed the accuracy check.

From 2004 through 2009, the overall failure rate for the OBD test equipment has been 1.1% or less. The 0.9% percent failure rate in 2009 maintains the improvement seen over the 5% OBDII audit failure rate in 2003.

Since the OBDII scanner accuracy check includes an OBDII RPM reading, if a workstation fails the OBDII RPM pickup check, it will also fail the OBDII scanner accuracy check.

[3] For one additional audit, the field investigator initially recorded a visual failure in error. The audit also had an accuracy failure. The auditor immediately re-audited the test equipment and corrected the visual failure, with results for the second audit showing that all items passed.

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.

Five workstations at five stations failed one or more parts of the OBD test equipment audit. These five failures represent 1% (5/526) of all audited workstations (lanes) and 1% (5/509) of all audited inspection stations. The five failures were equivalent to 0.4% of all 1,383 stations that conducted emissions inspections throughout the year and 0.4% of all 1,418 workstations that conducted emissions inspections throughout the year.

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

3.3 Auditing Equipment

For the 2009 pilot, twenty pieces of auditing equipment were obtained that were custom-built to the program's specifications. One goal of the pilot was to evaluate whether this equipment met the goals of being cost effective, easy to use and not susceptible to user error in the field. The equipment was designed to have no knobs or switches that can be inadvertently adjusted in the field. The RMV field investigators found the auditing equipment straight forward to use.

During the pilot, two pieces of auditing equipment required repair. One piece failed to communicate early in the pilot. The manufacturer determined that a component in the equipment was not performing properly in cold damp conditions. To eliminate this problem for future orders of auditing equipment, the manufacturer has modified the testing procedures for the auditing-equipment components. The ten audit records for the six audits that were conducted before this piece of auditing equipment was repaired, were removed from the data analysis.

The second piece of auditing equipment required repair when its OBD connector broke at one of the two points where it is attached to the audit equipment's box. Though cost effective, the audit equipment used in the pilot is designed for laboratory use where the equipment is not frequently connected and disconnected from OBD test equipment. The Agencies concluded that the use of a two- foot extension cable that stays connected to the audit equipment between audits would reduce the stress put on the connector.

Based on field experience during the pilot, the OBDII audit equipment carrying cases were modified so that the two-foot cable could remain attached to the audit equipment and an audit could be conducted without removing the audit equipment from its case. The change to the cases is expected to provide a modest increase in the speed of some audits and will reduce the wear and tear on the audit equipment.

3.4 Auditing Software and Database:

The goals for the auditing software and auditing database were to:

- provide easy-to-use auditing screens on the station's workstation, that could be accessed by RMV and MassDEP staff, and
- record the data entered on the workstation's auditing screens accurately in the auditing database.

The RMV field investigators found that the displayed auditing screens were straight forward. Investigators reported that the OBD test equipment audit added from one to ten minutes to an RMV field visit. The field investigators reported that audits usually added less than 5 minutes to the station site visit, but at an occasional station that did not have an easily accessible outlet or other power source, setting up the audit equipment took significantly longer.

Since audit failures were rare, the time estimates are based on passing audits. A failing audit would take longer because of the requirement to thoroughly document the details of the failure and because, for communication failures, the audit procedures requires retrying the audit with an alternate power source for the audit equipment.

Software and database issues were uncovered during the pilot auditing program that resulted in multiple audit records being created in the database for some audits.

The audit software used for the 2009 pilot did not provide an option of aborting the audit at any time. The inability to abort the audit caused multiple records to be created for some audits. In these cases, an audit failure for communication was recorded in the database even though the audit equipment was not connected to the workstation. In addition, it appears that the inability to abort may have lead to the creation of multiple records with communications failures if an investigator repeatedly pressed "yes" for "Do you wish to attempt to connect to the OBD connector again?" Field Investigators may have pressed yes repeatedly when they were setting up their auditing equipment, and were not aware that these "interim" attempts to communicate might be recorded as separate audit failures. In July 2010, the screens were modified to provide the choice of aborting the audit. This change allows investigators to exit the screen without recording a failing communication result. For the 2009 data, the extra records for created due to this problem were removed from the analysis.

In addition, the process for updating the database with records from the workstation also occasionally created duplicate audit records with slightly different time stamps. The contractor identified and corrected an issue that may have caused the duplications. These duplicates were removed from the data analysis. Analysis of 2010 audit data will determine if all sources of duplicated records have been eliminated.

The combination of the duplicated records and unintentional communication failures lead to the exclusion of 98 records for 33 audits from the 2009 analysis. All of these 33 audits

also had records of passing audits that were included in the analysis. An additional five records of communications failures at four workstations were deleted because it appears that an audit was not intended. There were no passing audit records for these workstations, and other data suggests that audits were not intended. For example, one audit comment included the word "test" repeatedly, and another record did not have a comment, as required for failures, even though that auditor reliably recorded a comment in all 38 of his passing audits.

Two improvements and corrections were identified in the software and database that will be addressed in future releases:

- The RPM read by the workstation will be recorded in the OBD audits data table.
- Two additional fields, PCM Module ID 2 and PID Count 2, will be added to the OBD audits table and the audit screens will display any values returned by the OBD test equipment for th ese fields. The audit screen currently displays blanks for these fields.

3.5 Audits Incorporated into RMV Site Visits

The pilot confirmed that the OBD test equipment audits can be incorporated into normal investigations and site visits conducted by the RMV field investigators. Though an audit may not be included in every site visit, most of the RMV's site visits will incorporate an equipment audit.

3.6 Recommended Next Steps for OBD Test Equipment Audits

In addition to the issues with the database and software mentioned above, the pilot identified two issues that Massachusetts plans to address during the next phase of equipment auditing:

1. A field investigator's visual inspection of the condition of each cable and connector determines whether the cable and connector condition merits a failing audit and the associated cost for a repair. During the pilot, the field investigators reported that the stations generally are taking good care of the OBD test equipment. However, for the pilot the field investigators tended to use the data from the functional communication test to make the final determination of whether the visual inspection of the cable and connector would pass. During the next phase of auditing, the RMV field investigators will have an opportunity to compare notes on how decisions are made about the cable and connector condition, and will discuss concrete examples of when the cable or connector passing and failing for the visual audits that will be consistently applied by field investigators.
2. Now that the OBD audit equipment is confirmed to be adequate for field audits, in 2010 RMV will obtain additional audit equipment, with additional communication protocols.