sierra research

Report No. SR02-02-02

Hands-On Audit Training for Mass- and Concentration-Based IM Programs

prepared for:

U.S. Environmental Protection Agency
Certification and Compliance Division

February 2002

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U.S. Environmental Protection Agency
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Under Contract No. 68-C7-0051
Work Assignment No. 3-05

February 2002

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Hands-On Audit Training for Mass- and Concentration-Based IM Programs

Table of Contents

Section page

1. INTRODUCTION 1-1
   Background 1-1
   Organization of the Report 1-3

2. INSIGHTS ON EQUIPMENT AUDIT FAILURES 2-1
   Recommendations 2-2
   QA/QC Elements 2-3
   Auditing Particular Programs 2-7
   Issues of Concern 2-9
   Sources of Audit Equipment 2-16
   Approximate Cost for Audit Equipment 2-21

3. TEST SYSTEM ACCEPTANCE TESTING 3-1
   Initial Acceptance and Beta Testing 3-1
   ATP Development and Performance 3-3
   Beta Testing 3-4
   Required Resources and Time 3-5
   Testing of Non-BAR97 Equipment 3-6

4 AUDITOR TRAINING COURSE 4-1
   Classroom Training Description 4-1

APPENDIX A. EXAMPLE ACCEPTANCE TESTING PROCEDURE A-1

APPENDIX B TRAINING COURSE PRESENTATION B-1

1. INTRODUCTION

Under Work Assignment 3-05, Sierra has developed a training course for EPA that can be used to train auditors of decentralized concentration- and mass-based vehicle inspection test systems. The training materials (which are included in Appendix B) focus on quality control issues of all types (acceptance testing, calibration, and audit failures) and include Sierra's experience with the most common types of failures. This report is a supplement to the training materials and includes documentation of common equipment issues, proposed EPA and state actions to improve equipment quality control, an example acceptance testing procedure (provided in Appendix A), and issues related to auditing test systems. Also included are Sierra's insights into quality control issues based on observations from working with several states.

Background

Under the Clean Air Act Amendments of 1990, metropolitan areas with the most serious air quality problems are required to implement so-called "enhanced" vehicle emissions inspection and maintenance (I/M) programs. One element of an enhanced program is a test procedure that is more effective than the simple idle tests used in "basic" I/M programs. Two different test procedures for exhaust emissions testing in enhanced programs have been approved by EPA: the "IM240" test and the "Acceleration Simulation Mode" (ASM) test. The IM240 test and several shortened versions of it (e.g., IM147) involve "transient" (i.e., stop-and-go) testing. In contrast, the ASM procedure involves only steady-state operation, but with a load on the vehicle that represents an acceleration mode Both of these procedures have been shown to be capable of separating vehicles with excessive exhaust emissions from other vehicles; however, the accuracy of the emissions results depends on ensuring that the test equipment is accurately calibrated and operating properly.

A number of enhanced I/M programs are implementing one or both of the two common ASM modes (i.e , the 2525 and the 5015). Most of these programs have implemented ASM testing on a "decentralized" basis in which existing vehicle repair shops are licensed to perform such testing. Under this type of system, licensed shops must purchase and use test systems produced by one or more equipment manufacturers, based on equipment specifications developed by the program All specifications for ASM testing programs are in turn based on equipment specifications developed by the

California Bureau of Automotive Repair (BAR)* and also published by US EPA.** In addition to spelling out the test procedures to be used in conducting the ASM tests, the US EPA and BAR97 specifications include required certification, calibration, and audit procedures. Specifications developed by other states are modified versions of these procedures.

Both ASM and transient testing programs include new components that were not previously required for idle testing, including the measurement of NOx, the measurement of emissions control system status and RPM via the OBDII port on a vehicle, and the use of dynamometers. Transient programs require a more complicated system for exhaust measurement than ASM systems, due to the need to measure exhaust flow rate to calculate emission rates. Under EPA's IM240 procedures, exhaust is diluted to a constant volume using a constant volume sampler (CVS). Some decentralized transient testing programs specify "VMAS" flow measurement equipment, which uses a proprietary technique to measure vehicle exhaust flow at a lower cost than a CVS system. The availability of this equipment, coupled with the use of BAR97 analyzers and dynamometers (used in a transient test mode), has enabled several states (i.e., New York, Massachusetts, and Rhode Island) to implement transient mass emissions testing in a decentralized network. However, although VMAS systems are already operating in the field, development of well-designed calibration and other quality assurance/quality control (QA/QC) requirements has lagged behind the implementation of these systems, leading to concerns regarding their accuracy during in-use service (in part because they are not specified by BAR and were introduced after the last revision of the federal test system QC requirements). OBDII interrogation firmware is also being incorporated into the design of most decentralized test systems due to Federal requirements related to OBDII I/M checks, but no quality control procedures have been proposed to date.

The proliferation of these new, increasingly sophisticated decentralized emissions test components means that this equipment is being used more and more by vehicle inspectors who are less able to understand how calibration and quality control practices may affect test accuracy. The combination of this factor with the absence of industry-accepted QA/QC procedures raises significant concerns regarding the overall accuracy of enhanced decentralized testing (Some of these systems are being used in the centralized test environment as well.)

CFR40, Part 51 Section 363(c) requires that overt audits of the decentralized test systems be performed twice a year. To help states develop these programs by increasing the amount of information available on QA/QC procedures for these new sophisticated test systems, EPA contracted with Sierra in 2000 under Work Assignment 2-05*** to provide EPA with emissions test equipment audit procedures. These procedures cover all test

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* "BAR-97 Emissions Inspection System Specifications," California Bureau of Automotive Repair, May 1996

** "Acceleration Simulation Mode Test Procedures, Emissions Standards, Quality Control Requirements, and Equipment Specifications," US EPA, EPA-AA-RSPD-IM-96-2, July 1996

*** "ASM Audit Guidance," US EPA Contract 68-C7-0051 Work Assignment No 2-05, September 15, 2000

system components including BAR97 gas analyzers, dynamometers, weather stations, engine RPM measurement devices, OBDII interrogation firmware, gas cap and vehicle pressure testers, and VMAS flow measurement devices.

As IM programs begin to mature, more and more states are now beginning to evaluate their program performance. As part of this evaluation, they are beginning to examine the performance of their test equipment as required by CFR40 by implementing auditing procedures such as those developed under Work Assignment 2-05. Therefore, EPA is being asked more frequently by states to provide technical support to auditing programs in the field. For this reason, EPA has developed Work Assignment 3-05 to provide EPA IM staff with hands-on training of the audit procedures. This report is part of that Work Assignment in that it provides information on the initial acceptance testing of decentralized emissions test systems related to QA/QC (an example is provided in Appendix A) and the most common type of failures for each given audit procedure shall be discussed. In addition, the instructional materials from the classroom portion of the training are include in Appendix B and should allow EPA staff to training additional EPA and state program staff.

Organization of the Report

This report is divided into four sections. Following this Section 1 introduction, Section 2 provides insights on equipment audit failures, and costs and sources of auditing equipment. Section 3 then discusses test system acceptance testing, and Section 4 describes the training materials presented in Appendix B.

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2. INSIGHTS ON EQUIPMENT AUDIT FAILURES

This section of the report includes detailed descriptions of issues that are not obvious by simple examination of the audit procedures and forms. It is meant to provide completely candid expert opinion on the state of I/M testing today, in particular on ASM testing, including the use of the VMAS emission measurement equipment. This section also provides the names of vendors and approximate costs for audit equipment.

The comments and opinions provided by Sierra are based on our significant firsthand experience in working with states, contractors, and equipment vendors, and our knowledge gained by frank discussions with a broad spectrum of I/M stakeholders. Because many of the statements made in this section of the report are qualitative assessments of particular areas of the I/M test process (quantitative documented findings from firsthand involvement in I/M test activities cannot be made due to confidentiality requirements with Sierra's clients), it is possible that groups within EPA, states, contractors, and equipment vendors could take issue with specific statements that are deemed to be overly subjective from an individual's perspective. Despite this, Sierra is of the opinion that these comments represent an accurate assessment of current issues related to design, checkout, operation, and audit of ASM and VMAS test systems.

This section is a supplement to the audit training course (covered in Section 4 and Appendix B) and covers:

1. Recommendations to improve the QA/QC by EPA and states;

2. The relationship between routine program audits and other equipment-related quality assurance and quality control (QA/QC) activities, and how these activities fit together,

3. Issues that technical staff should be aware of in performing the equipment audits; and

4. Recommendations on the equipment needed to perform the audits (e.g , portable weather station, RPM and OBDII simulators, etc.), possible sources for this equipment, and approximate costs for each item.

Each of these elements is covered in the following sections.

Recommendations

The following recommendations are divided into two groups. The first involves recommended actions for EPA to pursue in addressing existing emissions test system-related concerns. *The second group of recommendations is aimed at the state I/M* programs, and actions they should take to improve the quality of their emissions test program.

EPA Issues -

1 EPA should make readily available the audit guidance created under Work Assignment 2-05 so that states can use this as a reference for performing auditing.

2. EPA should develop a reasonable policy and guidance on how it intends to work with states to give them the time they need to ensure that the test equipment is operating properly prior to program rollout (proper time for acceptance testing and beta testing).

3. EPA should become more proactive in judging the technical adequacy of new test systems and procedures before they are produced and installed in a program. This would include holding states to a much higher performance threshold than currently exists for testing and verifying the operation of new prototype systems prior to allowing their use.

4. EPA needs to establish some type of approval process for new test systems, similar to but less cumbersome than the High-Tech Test Committee process used to develop the initial details of EPA's IM240 guidance.

5 EPA should use the above approval process to ensure that new test systems are well designed and incorporate adequate QA/QC elements.

6. EPA needs to establish a mechanism to ensure that technical, certification, and audit information about test systems is shared among the states. EPA should post information about state audit problems on the EPA website or distribute it to interested states using some other suitable mechanism.

7. EPA should add calibration and quality control procedures for the use of VMAS to CFR 40 Part 51 Subpart S Appendix A

State Issues -

1. States should allow sufficient time in implementing new program designs or equipment for a comprehensive acceptance and beta testing process designed to minimize the occurrence of test system bugs after program rollout.

2. States should ensure that standard audit display screens covering all applicable test system components are included in the specifications for the equipment, and verify the functionality of all such screens as part of the acceptance testing process prior to program rollout.

3. States should use the audit procedures and related equipment recommended in Work Assignment 2-05 to perform sufficient acceptance testing to verify the basic functionality of emissions test system hardware prior to program rollout.

4. States should incorporate the software verification elements described below into the acceptance testing process, in order to verify all required functionality and identify/resolve any software bugs prior to rollout.

5. If a manufacturer is basing its compliance on a statement of compliance with other specifications, such as BAR97 or NYTEST, the state(s) should contact the applicable agency (e.g., the California Bureau of Automotive Repair [BAR]) during the acceptance testing process to verify that the proposed test system has in fact been certified for use. The state(s) should keep current with proposed and required changes for manufacturers to maintain their certification.

6. States should subject all test systems to a well-designed and thorough beta testing process following the completion of acceptance testing.

7. States should include analysis of the test record database and all data files being produced by the test systems sent to that database in the acceptance and beta testing verification process.

QA/QC Elements

The auditing of ASM and other enhanced emissions test equipment is only one component of what should be an integrated quality assurance/quality control program aimed at ensuring that the equipment is properly designed and maintained. This QA/QC program can be divided into three primary elements:

1. Initial acceptance and beta testing of the equipment;

2. Ongoing, automatic calibration checks programmed into the equipment; and

3. Equipment audits that are performed on a routine basis.

All three of the above elements are critical to ensuring that the equipment continues to work properly and produce accurate test results. Details on acceptance and beta testing are given in Section 3 of this report, and issues related to calibration and audit elements are provided below.

Calibration Checks – Calibration checks are the second of the primary QA/QC elements that are essential to ensuring that emissions test systems are producing accurate test results. A range of automated calibration checks is incorporated into BAR97 and other enhanced test systems. Most of the test systems are (or should be) designed to require the performance of a passing calibration on a specified time interval (e.g., every 3 days, weekly, etc.). If the check is not performed or the test system fails its calibration, the software is designed to lock out the unit from further testing until a passing calibration is performed.

Verifying the functionality of the calibration checks during the acceptance testing process provides assurance that the equipment will continue to operate within allowable limits and thus produce acceptable test results after the test systems have been rolled out into the field. The calibration checks also serve to ensure that the equipment is properly maintained, since otherwise it will not continue to pass calibration. It is therefore important that the equipment specifications and resulting control software contain a full range of calibration checks aimed at all hardware components.

For BAR97 components, the calibration checks are relatively straightforward. They typically involve a required 3-day gas bench calibration, a dynamometer coast-down check, and calibration of the gas cap tester (if the system is so equipped), as well as a 3-day leak check of the sample system. This latter element is usually performed in combination with the gas bench calibration. These checks basically ensure that the equipment is operating within specified parameters (as coded into the control software).

For non-BAR97 components, the situation is complicated by the lack of documented EPA guidance or other specifications. Neither EPA guidance nor the NYTEST specifications contain any information related to VMAS calibrations. This has necessitated a significant effort on the part of Massachusetts and its network contractor (Keating Technologies), the manufacturer of the VMAS systems (Sensors), and Sierra to develop and implement the necessary calibration checks for this component. While significant progress has been made in this area in the Massachusetts program, we are unaware to what degree similar functionality has been or is being developed in the other VMAS-based programs (i.e., New York and Rhode Island).

The fact that the VMAS QA/QC functionality is being developed on the fly after program rollout is distressing and is a potential indicator of more problems to come. As noted above, additional test systems using new emissions and/or flow measurement technology are currently under development. Unless EPA handles the approval of such equipment differently than the NYTEST units, these test systems will have similar, if not worse, QA/QC problems. EPA needs to begin now to establish some type of approval process for such systems. Restarting the High-Tech Test Committee process that was used to develop the initial details of EPA's IM240 guidance is not recommended However, some type of similar but less cumbersome method is needed to ensure that new test equipment is well designed and incorporates adequate QA/QC elements. Currently there is no mechanism to ensure this

Equipment Audits – Audits are the last of the three primary QA/QC elements. These need to be conducted on a regular basis to verify that the test systems are accurately measuring emissions. They also serve as a check on the ability of the automatic calibrations to maintain equipment performance within specified parameters.

For the most part, audits should function on a pro forma basis; i.e., they should show that the equipment is meeting all applicable performance standards. If the test systems are verified during acceptance testing to be meeting all applicable specifications (including relevant calibration checks) and continue to pass all their calibration checks, they should easily pass audits as well. However, this is not the case in almost all enhanced programs across the country, particularly in the decentralized programs. There are a number of reasons why audit failures are occurring at high rates in many programs, including those outlined below.

1. In hindsight, some elements of the BAR97 specifications and related EPA ASM guidance come relatively close to the performance limits of the available technology (i e., gas benches).

2. The prototype systems submitted by the manufacturers and tested by BAR during the BAR97 certification process were largely hand-picked units whose performance was superior to the average test systems.

3. A typical BAR97 test system, particularly after it has been in the field for some time and suffered a commensurate degradation in performance, does not perform nearly as well as the gold standard units tested and certified by BAR.

4. Certain design features that are required by federal regulation, and which would address some of the audit problems, are not incorporated into the test systems nor is EPA requiring them to be. The most obvious example of this is the lack of any multipoint gas bench calibrations.

5. In some cases, widespread audit failures are seen by the affected states, manufacturers, and contractors as a problem with the audit procedures rather than the test systems.

Sierra does not have a readily available solution to the audit problems that are being encountered in many programs. We also recognize that EPA cannot simply address this issue by requiring that states adopt more stringent QC procedures. For example, while implementation of multipoint calibrations might eliminate most BAR97 bench audit failures, it is clear that EPA cannot just begin telling states to go to such calibrations. The problem is that the existing test systems have been built within the constraints of existing EPA guidance and BAR97 specifications; any tightening of the specifications is likely to lead to the need for a significant redesign of the test system components, which would be impractical.

Conversely, some if not all the manufacturers appear to also be at fault because they built systems that could not perform to the guidance/specifications during in-field operation.

This has led BAR to pressure the manufacturers to incorporate various improvements or enhancements into their systems in an attempt to upgrade performance to allowable limits. The end result of this effort is unclear at this time; i.e., it is not known whether the improvements will in fact enable the systems to begin meeting the audit limits in California. In addition, it is unclear to what extent these improvements will migrate to other programs. BAR is being very quiet about its discussions with the manufacturers, and as a result it is unknown to what extent other states are aware of the upgrades that are currently underway in California The manufacturers will certainly not volunteer this information to other states.

This situation further supports the need for some type of mechanism aimed at ensuring that this type of information gets shared among the states. At present, this happens only when specific questions are addressed to California (or another state). We also believe that many states tend to downplay any problems they are encountering to avoid creating the perception among the public, EPA, or other parties that their programs are in trouble or are suffering from a loss in effectiveness. For this reason, Sierra recommends that EPA consider requiring more frequent reporting of audit problems by states. Under this approach, states that have a component audit failure rate above a certain threshold level would be required to report that rate on a quarterly basis, along with a detailed explanation of the reason(s) for the failures and what the state is doing to address the problem in an expeditious manner. This information would in turn be posted on the EPA website or distributed to interested states using some other suitable mechanism.

Audit Feedback – Under 40 CFR section 51.363(c), equipment audits are to be conducted at least twice per year. Test system components specifically described as requiring an audit in this section include the gas bench, sample system, CVS flow measurement device, FID, dynamometer, and pressure and purge test devices. The gas cap tester, VMAS unit, OBDII interrogation link, weather station, and RPM measurement devices are not explicitly listed in the section but should also be included in the audit. Obviously, the components to be audited in any particular program will depend on the design of the applicable test system(s).

Isolated audit failures will occur since even equipment that is well calibrated and maintained will fail on occasion when subjected to a more detailed audit procedure. These failures are not considered of significant importance except for ensuring that they result in the applicable test systems being quickly returned to proper performance.

Of much bigger concern is the problem of repeated audit failures noted above. A critical link in the QA/QC effort is to have an effective feedback mechanism that can be used to address repeated failures through changes in equipment design or performance parameters. For example, such failures may be addressed by redesign of one or more components, which would then need to be subjected again to some type of certification or acceptance testing process prior to being rolled out into the field. Another approach might be to change the automated calibration procedures (e.g., increase their frequency) to address such audit failures. These examples show the interrelated nature of the three QA/QC elements. Each depends on the other and none by itself is sufficient to produce properly designed and operating systems.

Audit Frequency – Another concern is that many states may be performing substantially fewer equipment audits than the number specified in 40 CFR 51.363; i.e., two per year per test system. During a presentation at the Clean Air Conference in Colorado, the audit supervisor for BAR indicated that the agency currently has a total of eight auditors who are responsible for performing equipment audits. He also indicated this number was a recent increase from the previous total of four auditors.

There are currently about 7,800 licensed Smog Check stations in California, most of which are located in the enhanced program areas. The current total of eight auditors is clearly insufficient to perform two equipment audits per year at each of these stations. If it is assumed under a best-case scenario that an auditor can perform an average of four audits per day and there are 250 working days per year, the eight auditors would be capable of performing a maximum of 8,000 audits per year. This is only about half the required number. In addition, given the relatively high frequency of failing audits in the program, the assumption that each auditor can average four audits per day is overly optimistic (In the case of a gas bench audit failure, the bench is recalibrated and the gas audit is then repeated, thus significantly extending the time required to complete the audit.) For this and other reasons, Sierra believes the actual number of equipment audits currently being performed in California is much less than 8,000 per year.

The above example is not intended to single out California per se, but rather to illustrate the potential magnitude of this problem. The California Smog Check program is widely regarded as being one of the best managed decentralized I/M programs in the country, particularly with regard to technical and equipment issues. One demonstration of this view is the nearly total acceptance by other states of BAR certification as adequate proof of test system hardware compliance. However, it is clear that insufficient resources are being allocated to equipment audits in California. BAR's annual budget for administering the Smog Check program and overseeing other vehicle repair activities in the state is in excess of $80 million. If BAR, with this budget, is not coming close to performing enough audits, what is the situation in other states with much more limited resources?

Auditing Particular Programs

The audit procedures and forms developed under WA 2-05 are in a modular fashion, with each audit module aimed at individual equipment components (i.e., the gas benches, dynamometer, VMAS flow measurement, etc.). The objective of this approach was to improve the utility of the materials for use in audits performed by EPA and state I/M program staff. Those modules to be used in auditing a particular program can be selected based on which test system components are applicable to the program.

Once the relevant modules have been identified, they can be combined in a logical order to perform audits of the test systems being used in the program. Typically, the sample system leak check and gas analyzer audit are performed first. (The leak check is always performed before the gas bench audit.) The remaining audit elements can be combined in whatever manner makes the most sense for the test system being audited. For example, the software menus that must be accessed to perform some functions may be configured in such a way as to make it easier to perform these audit elements in a certain order.

Table 1 has been developed as a guide to what modules should be used to conduct audits in each current enhanced I/M program. The information contained in the table represents Sierra's understanding of the present status of the program, based on a detailed survey we recently completed of all the programs. Significant changes in program status can and are likely to occur in the future. In particular, many of the programs included in the table are planning on implementing OBDII checks in the next 6 to 12 months.

Table 1
Modules to Use in Auditing Current Enhanced I/M Programs[1]

Program	Leak Check	Gas Bench	Transient Dyno[2]	ASM Dyno[2]	CVS Flow[3]	VMA S Flow	Gas Cap	Pressure Tester	OBD II	RPM	Weather Station
AZ/Phoenix	•	•	•		•		•	•			•
CA/enhanced areas	•	•		•			•			•	•
CO/enhanced areas	•	•	•		•		•		•	•	•
CT	•	•		•			•			•	•
DC	•	•	•		•		•				•
DE	•	•					•	•		•	
GA	•	•		•			•			•	•
IL	•	•	•		•		•		•		•
IN	•	•	•		•		•				•
MA	•	•	•			•	•			•	•
MD	•	•	•		•						•
ME							•		•		
MO	•	•	•		•		•		•	•	•
NJ	•	•		•			•			•	•
NY/New York City	•	•	•			•	•		•		•
OH	•	•		•			•			•	•
OR/Portland	•	•	•		•		•		•	•	•
PA/ Philadelphia	•	•		•			•			•	•
RI	•	•	•			•	•			•	•
TX	•	•					•			•	•
UT/Salt Lake	•	•		•			•			•	•
VA	•	•		•			•			•	•
WA/Spokane	•	•		•							•
WA/ Vancouver	•	•		•			•				•
WI	•	•	•		•		•		•		•

[1] In addition to the individual modules shown in the table, a visual inspection of the test systems would be conducted as part of all equipment audits

[2] Audit procedures for both types of dynamometers are included in a single module.

[3] CVS audit procedures have not been developed since this work assignment is focused on auditing ASM- and VMAS-based test systems CVS flow measurement is shown in the table for completeness, see the EPA IM240 guidance for how these units should be audited

An experienced auditor should be able to perform a full audit of an ASM/evaporative emissions test system in roughly 45–60 minutes. It is estimated that an additional 30 minutes will be required to audit a transient dynamometer, and another 30 minutes to audit a VMAS flow measurement device. Less experienced auditors will take longer (i.e., as much as double the time) to complete each of the audit procedures.

Issues of Concern

As noted in the work plan for this work assignment, Sierra is to highlight issues that EPA technical staff should be aware of in performing audits of emissions test systems. In performing acceptance testing and audits of a range of emissions test systems in various state I/M programs, Sierra has identified a number of problems and concerns with the equipment. These are sufficiently widespread to lead us to conclude that many existing test systems in other programs probably also suffer from similar problems. These concerns are therefore highlighted below to ensure that EPA is aware of and checks for the type of problems observed in the field by Sierra. Note that some of the highlighted examples involve software issues that should be checked during acceptance testing, rather than hardware issues that can be checked during an equipment audit.

Audit Menus - Audit menus are generally an afterthought to most IM programs in the development of their specification. Most auditing programs have difficulty accessing the information needed to perform all of the portions of an audit. This is in part because some of the raw readings are available only through manufacturer field service representative access, and generally state auditors do not have this type of access because manufacturers do not want the state personnel to accidentally change setup parameters. The requirements for audit menus to display all of the required information for performing an audit need to be clearly defined in equipment specifications and checked during ATP.

Dynamometers -

1. Proper error checking of dynamometer load is not incorporated into the control software on some test systems; in some cases, the software may not be checking to determine if a load is even being applied. For example, Sierra disconnected the power to the Power Absorbing Unit (PAU) of the dynamometer and ran a test without it being detected and the test being stopped.

2. Problems with application of the correct load have been found in both steady-state and transient uses of BAR97 dynamometers. For steady state (ASM) testing, the problem is usually related to incorrect lookup of the vehicle

testing parameters (see the next item). For transient testing, although BAR did conduct some certification of the BAR97 dynamometers to be able to perform "diagnostic level inertia simulation," inertia simulation is not used in CA.

3. It appears that during certification, at least one manufacturer used software running on a PC to perform transient feedback control of the dynamometer. When the dynamometer was certified, the only operation the PC was performing was controlling the dynamometer. Testing by Sierra using the Sierra Research Dynamometer Tester discovered, however, that the manufacturer was using "Virtual Inertia" (e.g., applied load based on assuming the drive trace was driven perfectly) as opposed to using feedback control from a computer. When asked to use feedback control, the manufacturer used feedback control from the PC in the test system. Unfortunately, this PC is also responsible for updating the drive trace on screen, sampling gas values, and performing a plethora of other simultaneous tasks. Using this configuration the manufacturer has not been able to meet the response time criteria, and these systems are currently in operation in testing programs.

4. There are three problems that have been observed with the use of the EPA/Sierra Lookup Table (ESLT). First, some vendors are simply not looking up the vehicle information in the lookup table correctly. This needs to be throughly tested during ATP to prevent this from occurring in the field.

   Second, some locations are not updating the ESLT as frequently as needed, even though important changes are made (even to older model years data) between updates. The problem with performing updates is due to limitations of the data systems some states use that do not allow for revisions to the lookup table to be downloaded. The only option programs have in this case is to have the manufacturer's field service representatives manually load a revised lookup table when they visit the test stations. This is a slow, tedious process and it is difficult to ensure all stations have received the update in a short period of time. In addition, the recent decision by EPA to no longer fund the ESLT and the switch to OBDII testing are creating further uncertainty for states as to the need to update the lookup table data in the field.

   Third, many testing programs are not using the "by model year" defaults contained in the ESLT, but are using the older defaults that were contained in previous EPA guidance. These are based only on vehicle type and number of cylinders. Average vehicle weights based on these characteristics have changed over the years, which led to the development of model year specific defaults that are more accurate. This problem is exceptionally important if either of the two previously mentioned problems (incorrect lookup or old ESLT data) is present because in both of these cases the system may switch to the defaults if the correct value cannot be found.

   One last issue is that the test programs in many locations are not maintaining the ESLT vehicle characteristic identification (VCID) number in their

databases. Some programs are creating their own ID number, which makes it difficult to trace data back to the ESLT. In addition, if someone is attempting to compare data for specific makes/models of vehicles between states, it is much more difficult if the VCIDs used by the states are different. If the ESLT VCID is used and stored in the test record, one can be more certain that the correct testing parameters were used for testing the vehicle and the data would be easier to compare between states.

5. No axle weight scales are being used with BAR97 dynamometers in ASM programs besides California to compute generic tire/roll loss (GTRL) for the test vehicle, despite the fact that it is a BAR97 requirement. The equipment manufacturers are instead using a variety of approaches to set GTRL, including using the values in the ESLT or values based on a hard-coded axle weight or half of the GVWR for the test vehicle. These latter two approaches are clearly problematic.

   The absence of axle weight scales is also an example of how equipment manufacturers are claiming test systems are BAR97-certified although the configurations being used in other programs are not those that were certified by BAR.

6. Currently the ESLT includes only the generic tire/roll interface losses for 2WD testing. Some states are now performing testing of AWD vehicles and vehicles with traction control on AWD dynamometers. Therefore, a method is needed to determine the proper GTRL for vehicles tested in AWD mode. Sierra has developed a method that EPA has approved to calculate AWD GTRL. This method should be included in revised ASM and IM240 guidance to ensure that these vehicles are loaded properly when tested.

7. Roll bearing temperatures are not being checked to compensate for changes in parasitic losses with temperature. Thermocouples are installed in the hardware but the data from the sensors are never used by the control system to adjust the parasitic losses for temperature. Also, one manufacturer's software had the ambient temperature and the bearing temperature signals reversed.

8. In some cases parasitic losses were being subtracted twice (at both the VID and the test system), causing all tests to be conducted with too low of a load. Two manufacturers were found to have other problems correctly accounting for parasitic losses. In one case it appeared to be an error in the calculation of parasitic losses in the software; in the other, it is clear that the manufacturer deliberately hard-coded the parasitic losses (i.e , so they were fixed for all tests and ambient conditions).

9. BAR97-certified dynamometers come equipped with a motor for automating the spin up of the dynamometer. This motor is used for spinning up the dynamometer to perform coast down checks and parasitic loss determinations. Since the dynamometers were originally designed to perform the BAR tests

(the ASM 5015 and ASM 2525), the motor is required to get the dynamometer only up to just over 30 mph. In New York, these BAR97-certified dynamometers are used for transient testing up to 56 mph. The dynamometers are incapable of determining the parasitic losses or of performing a coast down check at such a high speed. This could be leading to errors in loading at higher speeds.

10. One dynamometer vendor has made changes in the gearing between the power absorption unit and the roll set in programs where its dynamometer is used for transient testing. The change in configuration was never tested by BAR and the impact on testing accuracy is unknown.

Analyzers -

1. The NOx outlet was being vented in a manner that an unscrupulous inspector could easily change the reading by partially covering the outlet. This was changed from the configuration certified at BAR, but was still represented as "BAR Certified." The vendor said the NOx cell had been moved to the outside of the analyzer to allow the customer to be able to replace the NOx cell, without having to have a service technician come out and do it. Obviously if customers can access the NOx cell, they can tamper with the data from the NOx cell.

2. Testing in several programs found that several of the test system manufacturers are not properly time aligning the gas emissions with the drive trace. In one instance, although the exhaust gas being analyzed passes through the HC/CO/CO2 bench and then through the NO analyzer, the time alignment was the same for all gases. This caused the NO emissions to be improperly time aligned with the trace. This can cause problems in steady state testing programs and cause more significant errors in transient testing programs. This is because the second by second exhaust gas concentrations and the second by second flow rates are multiplied together to achieve the mass emission rate. If they are not both time aligned correctly, this will lead to incorrect calculation of mass emission rates.

3. The original test data from New York stated that proper sample conditioning (e.g., a chiller) appears necessary to improve emissions measurement accuracy However, only one decentralized test equipment manufacturer is using a chiller in its system and this system is not used in any of the transient testing programs. No decentralized test equipment manufacturer is using a chiller in any of the three decentralized transient testing programs (New York, Massachusetts, and Rhode Island).

4. NOx electrochemical cells are being found to perform very poorly and their performance is degrading well before the one-year lifetime commonly believed for these units. Unfortunately, the only inexpensive NO measurement method to date has been the City Technologies electrochemical cell. This cell has a relatively slow response time, which is problematic for states using the cells for

transient testing. BAR recently has proposed a change to the allowed T90 response time of the cells from 6.5 seconds max to 9.5 seconds max. For steady state testing, as long as the data are time aligned and if one assumes that the pollutant concentrations will be fairly constant, then this change is not significant. For transient testing programs, however, this change, which BAR has allowed, will add more inaccuracy to the calculated emission rates from the test since the emission levels during a transient test can change rapidly.

5. Gas benches on new test systems have been found to fail audits when being started up for beta testing. Some manufacturers have resorted to doing a "Cal High, Cal Low" procedure every time a calibration is required, instead of "Cal High, Check Low." "Cal High, Check Low" provides a check that the calibration curve fit between the high calibration point and the zero point is correct. The "Cal High, Cal Low" procedure has no check of the calibration curve fit and therefore the performance of the bench is never checked during a calibration and failures will only be detected during audits.

6. Some test system manufacturers are using the old humidity correction factor and have not yet begun to use the revised humidity correction factor. The revised humidity correction factor has the advantage of working over a wider temperature range than the previous version. In other cases, the incorrect revised formula contained in the 1998 guidance has been used and not corrected.

7 CFR 40, Part 51 Appendix A to Subpart S (I)(d) states that "high volume" stations (those performing more than 5,000 inspections per year) should perform a calibration every four hours as opposed to every three days. In addition, monthly multi-point calibrations are required as per section (I)(f)(1)(B). The only state that currently reports differentiating between low and high test volume decentralized stations is North Carolina. North Carolina also reports a low audit failure rate (less than 5%).

VMAS Units - At the time CFR 40, Part 51 Appendix A to Subpart S was adopted, VMAS was not being used in the field so no specific quality control checks for VMAS were specified. Appendix A (II)(b) does include checks for CVS-based flow measurement, but there are major differences between CVS- and VMAS-based flow measurement that make it impossible to apply the CVS-based quality control checks to VMAS For this reason, states have worked with Sensors (the manufacturer of the VMAS) to develop quality control procedures for the VMAS. Still, several open issues remain that can contribute to errors in measurements.

1. The VMAS unit determines the dilution ratio (exhaust gas to supplemental air) by comparing the oxygen content in the raw vehicle exhaust to the oxygen content in the diluted exhaust flowing through the VMAS. Unfortunately, the oxygen sensor in BAR97 analyzers (which measure the raw exhaust) have slow response times and BAR specifications did not require the oxygen sensor to pass a quality control check (there are no pass/fail criteria in the BAR specifications for the oxygen sensor) Therefore, even if the oxygen sensor in

the BAR97 analyzer is not functioning, the software will still allow testing to occur. When this happens, the dilution ratio will be incorrectly calculated due to the poor quality of the raw exhaust oxygen content measurement.

2. There is currently no EPA-specified method for auditing the oxygen sensor in the VMAS unit. Sensors has suggested a technique for auditing the sensor, and it has been included in the audit procedures developed under WA 2-05. New York and Massachusetts are using this technique on a research basis, but the technique is not being used in a consistent audit program.

3. There is no routine check the operator can perform to determine if the flow measurement system is operating properly. Working with Sensors, a weekly "hose off flow check" has been proposed to ensure the VMAS is still making accurate measurements of total exhaust/dilution air flow. The principle is that the VMAS should be pulling a fixed amount of air through it with the hoses off, and if this value changes, there may be something wrong with the flow measurement. This has not been implemented yet, and needs to be.

4. The VMAS unit compares the oxygen content in the diluted exhaust flowing through the VMAS to the ambient reading to make sure the collection cone has not accidentally or intentionally been moved away from the exhaust pipe. If the oxygen content in diluted exhaust flowing through the VMAS approaches ambient, the analyzer aborts the test because it believes the cone has moved away from the exhaust pipe. Unfortunately, on large decelerations (such as at the end of the IM240) many vehicles go into fuel cutoff to improve fuel economy. When the vehicle goes into fuel cutoff, the engine of the vehicle is essentially pumping air through the exhaust system. This air combines with the dilution air entering the VMAS and the oxygen content is nearly the same as ambient. The VMAS system interprets this as the cone having moved and aborts the test. The only way to prevent this type of abort is to remove this check

   Without this check, it is possible that the cone could move away from the exhaust and it will not be caught by the system. A back-up check using fuel economy could be used; however, as was previously discovered by EPA when a fuel economy check was proposed for the IM240 guidance, it is difficult to make this check stringent enough to be useful.

5. Many stations have mounted the VMAS units in various locations in their shops to get the unit "off of the floor" or out of the way Unfortunately, many of these locations require additional hose to get the exhaust to the VMAS unit. This distance and the extra resistance in the additional hose could change the transport time from the tailpipe to the VMAS. In addition, Sensors recommends that the exhaust exiting the VMAS pas through straight pipe for some small distance, and many shops are also not following this suggestion

6. The flow measurement in the VMAS is accomplished by a piezoelectric speaker on one side of the VMAS tube sending out a signal that is modulated by eddies coming off of a strut in the air flow and the rate of the eddies is read

by another piezoelectric sensor (microphone) on the other side of the VMAS tube. If the strut or piezoelectric device gets dirty, the flow reading will not be accurate. Currently some states require their software to instruct the inspector to clean the strut once a week, but there is no certain way to confirm that this has been done. Sensors has suggested that some sort of analysis of the variation in the flow could be used to determine if the strut was dirty, but to date, no one has implemented this type of check.

Weather Stations -

1. Ambient temperature sensors were improperly located inside the equipment cabinet, thus resulting in biased readings. The equipment manufacturers indicated that Sierra was the first to even ask that the temperature, humidity, and barometric pressure be displayed so auditors could check the reading against a standard measurement. Therefore, these cannot be evaluated in some instances unless the software has since been modified.

2. Sierra was also told that a manufacturer in another program hard coded the ambient readings (e.g , temperature and humidity) in all its test systems. The manufacturer provided two units for acceptance testing that properly monitored and accounted for changes in ambient conditions. After completion of acceptance testing, however, all units subsequently sold in the program area by the manufacturer had ambient temperature and humidity values hard coded into the software.

3. The weather stations are supplied with coefficients that are the calibration of the weather station (such as 1 volt equals 30 degrees). Sierra has witnessed a manufacturer's field service representative change a weather station in a unit and not enter the new calibration coefficients. When asked why he did not enter the new coefficients, he responded that he never changes them when changing a weather station because "they are all about the same."

Gas Cap Testers and Calibration Caps -

1. There are currently three types of gas cap testers in use. Stant, Waekon, and an internal version used in ESP analyzers. One of the gas cap testers has been found to give unreliable results and to have difficulty passing calibration checks. Stations generally repeat the calibration over and over until the unit passes the calibration and then use the tester for IM testing, most likely providing inaccurate results.

2. Some of the gas cap tester calibration procedures used by some vendors do not include checks of the accuracy of the system, but simply reset the calibration point. If one of the standards were incorrect (or, for instance, if the fail standard were left off during the fail portion of the calibration as opposed to using the fail standard), then the calibration would be incorrect. The calibrations set the pass and fail leak rates for the tester, so if an incorrect calibration is performed, then all subsequent tests could have incorrect results.

3. Fail standards provided by both Waekon and Stant have on occasion been found to be outside the allowed tolerance. EPA guidance requires these standards are checked before use and at six-month intervals. This is generally not currently done in IM test programs.

4. Providing the stations with an external pass standard leads to stations using the standard to fake tests. Several states have reported that when they visit stations, they have observed many are leaving the calibration pass standard attached to the gas cap tester. This implies that the stations are using this for performing tests.

Sources of Audit Equipment

Provided below are recommendations on possible sources of the equipment needed to perform the recommended audit procedures. Cost estimates for the recommended equipment are also provided in Table 2 at the end of this section. Note that these estimates are based on information obtained by Sierra and would be expected to change in the future. They also reflect the prices quoted to Sierra if we were to purchase the items; it is unknown if EPA or a state would be quoted a different cost.

Audit Van – Depending on which test system components are to be audited, a large amount of test equipment is required to perform the required audit elements. Due to these equipment requirements (including the gas cylinders that will need to be secured for transport), it is not possible to efficiently and safely transport the equipment in a passenger car. In addition, auditors can spend a great deal of time connecting and disconnecting the gas cylinder regulators. If gas cylinders are carried in a passenger vehicle, each time they are used the safety cap must be removed and the regulator must be connected for every cylinder In addition, some states have set up the interior of the audit vans to act as a workspace for the auditors This includes adding a desk, stool, storage cabinets, interior lights, and 120 VAC power for powering a laptop computer. Because compressed CO and NO gases are stored in the vehicle, it may be desirable to have both CO and NO alarms installed as well.

If audits will be performed on a regular basis, it is recommended that a full-sized van such as a Ford E-250 be used for transporting the required cylinders of gas and associated test equipment. This type of vehicle has the advantage that the rear interior space can be used for a work area and can include a desk, etc. In some cases, access to a gas analyzer is not possible by backing the audit vehicle into the shop allowing access to the gases

through the back door. A van allows for the gas distribution to be either from the rear or the side door of the vehicle, allowing different access to shops.

An alternative arrangement is to use a pick-up truck with a camper shell on the back and store the gases and equipment in the back. This prevents the auditor from sharing space with the gases which is safer in the case of a gas leak. However, it does not allow for work space and the gases can only be accessed from the rear of the vehicle.

Gas Racks - Because gas cylinders are to be moved from location to location in a vehicle, they need to be housed in safety storage racks. Installation of a gas rack in a van also allows the cylinders to be permanently attached to panel mounted regulators, saving significant time for the auditors. Although the use of vans with gas racks installed is more expensive than using passenger vehicles, it will save costs through reduced time for the inspectors to perform an audit, and make for much safer transport of the gas cylinders.

Sierra has previously worked with Praxair to design a cylinder storage rack and manifold gas delivery system that will reduce the amount of time it takes to perform an audit while storing the cylinders safely for transport. The system includes a storage rack, regulators, and a manifold that will provide a single point where all the gases can be accessed in order to flow them during the audit. More information on this system can be obtained from the following contact:

John Ottosen
Praxair
(800) 860-3531 x6237

Audit Gases - For audit gases, high-pressure cylinders are recommended due to the cost savings compared to low-pressure cylinders. The part numbers listed below were provided by Praxair; however, the same gases can be obtained from any gas blender. All gases should be ordered as 1% analytical accuracy gases, 2% blend tolerance. The specs on the gases are listed below. Note that the oxygen in nitrogen blends are only needed for VMAS auditing.

- Zero air (Praxair Part No. EV MSE14)*: < 1 ppm THC, < 1 ppm CO, < 200 ppm CO2, < 1 ppm NO, 20.9% oxygen, balance nitrogen

- Low-range BAR-97 with NO (Praxair Part No. EV MSE9): 200 ppm propane, 0.50% CO, 6.0% CO2, 300 ppm NO, balance nitrogen

- Mid-1 BAR-97 with NO (Praxair Part No. EV MSE38): 960 ppm propane, 2.40% CO, 3.6% CO2, 900 ppm NO, balance nitrogen

* The recommended zero air blend is "BAR97" zero air, which has higher allowed impurity levels than recommended in the current EPA ASM Guidance Document

- Mid-2 BAR-97 with NO (Praxair Part No. EV MSE39): 1920 ppm propane, 4.80% CO, 7.2% CO2, 1800 ppm NO, balance nitrogen

- High-range BAR-97 with NO (Praxair Part No. EV MSE12): 3200 ppm propane, 8.00% CO, 12.0% CO2, 3000 ppm NO, balance nitrogen
- 1%, oxygen in nitrogen audit gas, AQ- or AS-size cylinder

- 8%, oxygen in nitrogen audit gas, AQ- or AS-size cylinder

- 15%, oxygen in nitrogen audit gas, AQ- or AS-size cylinder

Medium-sized aluminum cylinders (i.e., "AQ" or "AS" size) are recommended. Size "AQ" cylinders are pressurized to 2000 psig, contain 78 cubic feet of gas, are 7.25 inches in diameter by 33 inches high, and have a tare weight of 30 pounds. "AS" cylinders are also pressurized to 2000 psig, contain 145 cubic feet of gas, are 8.00 inches in diameter by 48 inches high, and have a tare weight of 48 pounds. They should be able to conduct approximately 200 or 400 audits, respectively. The AQ and AS cylinders are approximately the same price, but the AS cylinder contains twice the volume. Although the AS cylinders are 15 inches taller, they should be able to be mounted standing in a full-size van. For these reasons, we suggest using the AS cylinders. If ease of handling is a significant issue, the AQ size cylinders would be easier to move.

Regulators - The gas rack system mentioned above includes regulators as part of the manifold gas delivery system. Therefore, if that system is used, fewer regulators will be required. If the cylinders are not going to be permanently mounted with the gas rack as recommended, more regulators will be required. Since the regulators will not be used to deliver a constant flow rate for a long period of time, single-stage regulators (which are much cheaper than dual-stage regulators) can be used The four audit gases containing NO must have stainless steel regulators; these require a CGA660 fitting. The zero air and the oxygen in nitrogen mixes can use brass regulators; these require a CGA 590 fitting Both types of regulators can be obtained from any gas blender.

Three-Way Switching Valve and Air Flow Meter - For VMAS auditing, an additional three-way switching valve (i.e., containing 3 inlets and 1 outlet) to switch the low-pressure zero gas and the 8% and 15% oxygen blends is required. This can be constructed of brass, since no corrosive gases will be used with it. The valve should be capable of handling low-pressure gas (less than 30 psi). The output of the three-way valve should flow through a simple floating ball-type flow meter. Praxair manufactures a three-way valve with a flow meter output. The Praxair unit consists of a stainless steel panel with three brass inlet quick connectors (containing internal valves), which are piped to a manual five-way brass valve (the extra inlet ports are plugged). There is one common outlet, which is piped to a brass flow meter (with a 0-2 liters per minute capacity) with a metering valve. The outlet of the panel also consists of a quick connector with an internal valve. The unit can be obtained from:

John Ottosen
Praxair
Model SGE 1215V5-FM-QC
(800) 860-3531 x6237

Tubing and Connectors - The straight tubing is made of Tygon and the connectors are made of polypropylene or polyethylene. All materials are fairly resistant to the gases used. These are commonly found items; one source is listed below.

Ryan Herco, (818) 841-1141
Tubing - Item # 0010.071, 50-foot roll - Tygon tubing ¼" ID x 3/8" OD R3603
Connectors - Item #0717.015, Hose Tee.PP.¼"H x ¼"H x ¼"H
Barbed regulator connectors - Item #0675.056, MALE CONN PE ¾" x ½" BARBXMPT

For connection to the sample probe, "bubble tubing" that fits over the end of a sample probe is required. This is not very common, Sierra has found only one source for this item:

Fisher Scientific, (800) 766-7000.
Item # 14 170 13C, 1 case (50-foot roll) bubble tubing 1/4 in, VCAT 8889 224054

We believe the VCAT number is the actual catalog number, and the "Item #" is the part number. Although only a few feet of bubble tubing is needed for a single initial setup, the "bubble" portion will wear out over time and need to be replaced. Therefore, although 50 feet may seem excessive, it will be used over time.

Rubber Bands and Balloons - The rubber bands are used to attach the balloons to the "Tee" connectors. Any inexpensive size of rubber band will work The balloons should be of the normal oval shape and can be made of any type of normal rubber material

Portable Temperature and Humidity Weather Station (Psychrometer) - The temperature and humidity can be obtained accurately using a simple and low cost psychrometer. Sierra recommends the following battery-operated psychrometer:

Davis Instruments, (800) 368-2516
Catalog number ET87101
Model 22010

Barometer - A high-accuracy barometer is needed for use with the Smooth Approach Orifice (SAO) that is used for the flow measurement audits. We recommend an electronic digital barometer, since a mercury barometer would be more difficult and hazardous to transport. The following is an example of a digital barometer that we believe is accurate enough for use with the SAO:

Davis Instruments, (800) 368-2516
Catalog number DR639406
Model 740

Reference Gas Caps - Reference pass and fail gas caps can be purchased from either Stant or Waekon, at the numbers provided below. Past experience has shown that some of the reference caps are not as accurate as they are purported to be, and it is prudent to individually flow test each cap on a quarterly basis to ensure it is properly calibrated. Sierra recommends an audit agency either purchase equipment that will allow the caps to be flow tested and conduct its own certification of the reference standards, or send the reference caps out to be flow tested.

Stant - (765) 825-3121
Waekon - (800) 367-9235

RPM Simulator - Two models are available, one with a dial and one with push-buttons. The push-button model has settings for both 2500 and 700 RPM; the dial model can only accurately test 2500 RPM. The push button model is recommended for use in auditing. A source and contact are listed below.

Leistung Test Products, (414) 783-5537
Contact: Ray Niemeischek

OBDII Simulator - To determine if the OBDII test systems are working properly, a device that can simulate an OBDII system in a vehicle is needed. The device allows for setting of diagnostic trouble codes and readiness codes, and simulating RPM. Sierra has worked with EASE Diagnostics to develop an OBDII audit tool. For further information, contact the following:

EASE Diagnostics
Catalog Number OVT-2020-SW
Steve Golenski
570-465-9060
stepheng@obd2.com

Computer Laptop – We recommend that auditors use laptops to record the audit data. If audits are going to be performed on a regular basis, audit software should be developed and used in the field to reduce the incidence of calculation errors. If the dynamometer tester is going to be used, the laptop also needs to have a PCMCIA slot for connection to the tester.

Smooth Approach Orifice (200 to 500 SCFM) – An SAO will be used to check the accuracy of the CVS or VMAS flow measurement. The following vendor can provide an SAO to meet the program requirements. Contact the company for further information

Dick Muns Company, (562) 596-1559
SAO, 200 to 500 SCFM, for connection to a hose with a 4" ID, low-flow restriction

Stainless Steel 4" Air Flow Control Valve - A "blast gate" is commonly used to control the flow of air in ventilation-type systems. This same type of gate can be used to adjust the flow of air exiting the VMAS system. This type of device can be purchased from the following source:

McMaster-Carr, (562) 692-5911
Item # 1788K12
Model - 4" duct diameter, standard blast gate, full gate style

Dynamometer Tester - A dynamometer tester will be required to ensure that transient dynamometers are applying the correct load to test vehicles. Sierra has developed a portable, relatively low-cost dynamometer tester for this purpose. The tester, which can be integrated with the auditor laptop (i.e., the software for the tester will reside on the laptop), includes a data acquisition system, optical speed sensor, interface box, data acquisition card, and software. The cost of Sierra's dynamometer tester is $20,000. Further information on Sierra's dynamometer tester can be obtained from the following contact:

Michael St. Denis
Sierra Research
(916) 444-6666
mstdenis@sierraresearch.com

The only other dynamometer tester of which Sierra is aware was developed for the California BAR by Real Time Dynamometers. It is relatively cumbersome to use and costs approximately $450,000. Further information can be obtained by contacting:

David Amlin
California Bureau of Automotive Repair
(916) 255-1376

Approximate Cost for Auditing Equipment

Costs for all recommended audit equipment are provided in Table 2. These reflect the costs quoted to Sierra; i.e., if we were to buy the items. Note that a simple summation of the costs included in the table will not result in the total cost needed to equip an audit vehicle. Depending on the test systems to be audited, multiple units of certain items (e.g , gas regulators) may be required. In addition, installation costs for the initial setup of the audit vehicle, such as installation of the gas racks and other equipment, are not included.

Table 2 Audit Equipment Costs		
#	Item	Cost/Item
1	Audit van	--
2	Gas cylinder racks with regulators, plumbing and output panel	$10,000
3	High audit gas, AQ or AS size cylinder	$250
4	Mid-1audit gas, AQ or AS size cylinder	$250
5	Mid-2 audit gas, AQ or AS size cylinder	$250
6	Low audit gas, AQ or AS size cylinder	$250
7	1%, oxygen in nitrogen audit gas, AQ or AS size cylinder	$200
8	10%, oxygen in nitrogen audit gas, AQ or AS size cylinder	$200
9	20%, oxygen in nitrogen audit gas, AQ or AS size cylinder	$200
10	Zero air, AQ or AS size cylinder	$75
11	Single stage stainless steel gas regulators, CGA 660	$425
12	Single stage brass air regulators, CGA 590	$175
13	Three way switching valve and flow meter	$1,300
14	50 foot roll 1/4" ID x 3/8" OD Tygon tubing	$55
15	Hose tees, 1/4" x 1/4" x 1/4"	$2
16	Barbed regulator connectors	$2
17	50 feet roll of bubble tubing	$35
18	Balloons and rubber bands	$2
19	Portable temperature and humidity weather station (psychrometer)	$140
20	Barometer	$1,800
21	Reference "pass" fuel cap	$100
22	Reference "fail" fuel cap	$100
23	Vehicle pressure test audit tool	$650
24	RPM simulator	$250
25	OBDII simulator	$3,500
26	Laptop computer	$2,000
27	SAO, 200 to 500 SCFM	$5,000
28	4" blast gate valve	$15
29	Dynamometer tester	$20,000

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3. TEST SYSTEM ACCEPTANCE TESTING

Before a QA/QC program begins, it is necessary to first ensure that the test system software is functioning properly through the performance of a comprehensive acceptance test procedure. An example of a required acceptance test is the confirmation that the parasitic drag in the dynamometer is being calculated properly. Sierra has had the experience where one particular equipment manufacturer was not calculating the parasitic drag in the dynamometer properly. If this had not been found and corrected before the equipment went into the field, the test systems could have been failing audits and having a technician attempt to recalibrate the dynamometer would not have fixed the problem. As can be seen by this example, if the proper system operation is not confirmed during acceptance testing, the systems will have audit failures that will not easily be repaired.

Due to the importance of acceptance testing, this overview is provided to show how acceptance testing relates to QA/QC and auditing of test systems. Sierra has performed acceptance testing for several states on all brands of decentralized test equipment. Examples from actual acceptance testing are provided from this experience. In addition, Appendix A includes an example of an acceptance test procedure for a decentralized ASM test system.

Initial Acceptance and Beta Testing

Under this element, prototype units of the emissions test system (or systems) should be subjected to detailed acceptance testing prior to program rollout. This testing is needed to verify that the equipment as designed will result in proper vehicle tests and accurate emissions results. If comprehensive acceptance testing is not conducted prior to rollout, a program is virtually guaranteed to encounter substantial problems in test system operation that could plague it for months or even years.

Acceptance testing also sets the stage for the latter two QA/QC elements described in this report (calibration checks and equipment audits). For example, control software for all required calibration and audit procedures must be verified to be present and fully functional during acceptance testing. This would seem to be an obvious requirement; however, as mentioned earlier, audit functions in particular often appear to be added as an afterthought to many test systems

Acceptance testing must include both test system hardware and software. A detailed discussion of how such acceptance testing should be performed is beyond the scope of this work assignment. In general, however, the testing should address the issues summarized below.

Hardware Functionality – The functionality of the individual hardware components as well as the performance of the integrated system should be tested. To date, most program agencies have not conducted very thorough hardware testing, largely because they do not have the experience or resources needed for this effort. This has led many programs to simply specify that the hardware being provided by the test system manufacturer(s) must meet BAR97 specifications (or NYTEST in the case of VMAS-based testing). However, this approach has also proven problematic, primarily for the following reasons:

1. BAR97 and, to a much greater extent, NYTEST specifications are poorly documented and/or incomplete. Agreements between the manufacturers and BAR made subsequent to the release of the BAR97 specifications are not fully documented, making it nearly impossible to determine exactly what is meant by the term "BAR97 certified." The NYTEST specifications are very incomplete, with many key elements (e.g., VMAS operation) totally ignored in the written specifications. This leaves many important technical issues open to interpretation, making it very difficult to determine whether a particular system is compliant with the specifications.

2. While the equipment manufacturers claim their systems are BAR97 certified, Sierra has found that in a number of cases changes have been made in the systems being produced for other programs. This means that these systems are in fact not BAR97 certified; however, the program staff are typically unaware of this. The changes that have been made cover a range of complexity and significance. However, we have identified several instances in which a modification from the BAR97-certified configuration may be having a significant impact on resulting emissions readings. This issue is discussed in more detail in a subsequent portion of this section and in Section 2.

Sierra recognizes that most agencies will continue to have limited ability to perform their own hardware verification testing. However, we believe much of the audit procedures and related audit equipment recommended in Work Assignment 2-05 can also be used during the acceptance testing phase to verify the basic functionality of the hardware

We also strongly recommend that any state that relies on a manufacturer's statement of compliance with other specifications, such as BAR97 or NYTEST, as proof of compliance for its own program initiate a dialogue with the applicable agency (e.g., BAR, New York State DEC, etc.) well in advance of acceptance testing. This dialogue should really begin during the development of the subject program's bid documents and/or equipment specifications, and should be continued throughout the acceptance testing process. Manufacturer claims regarding BAR97 or NYTEST certification should be discussed in detail with the applicable agency, and guidance should be sought on how to check the prototype test system to confirm it represents the certified configuration. Photographs and other documentation can also be provided to help the certifying agency determine if the prototype system matches the certified configuration.

Software Functionality – The full functionality of the software needs to be checked during acceptance testing. This includes all test procedures incorporated into the program, calibration and audit procedures, and all other software functions. While this

testing is relatively straightforward, it can also be time consuming. This is particularly true for decentralized programs involving multiple test systems built by different manufacturers and/or a centralized vehicle inspection database (VID) that is integrated with the test equipment. Care needs to be taken in such cases that both the individual test systems and the fully integrated system are subjected to adequate testing. When bugs are found in the system, additional time is also required to troubleshoot and identify the source of the bugs, since it is often unclear whether they are occurring in the test systems, the VID, or the interaction between the two parts of the overall network.

As mentioned previously, an important element that needs to be checked during acceptance testing is the functionality of the menus and display screens needed to audit each of the individual components of the test system (e.g., analyzers, dynamometers, VMAS flow unit, weather station, etc.). Sierra's experience is that these menus and screens are often forgotten or added as an afterthought without much focus on making them user friendly. This can lead to substantial difficulties in conducting subsequent audits. It is therefore critical that full audit functionality be incorporated into the equipment specifications and verified during acceptance testing. Particular emphasis should be given to ensuring the following:

- All audit menus, functions, and display screens are user friendly and do not require unusual access (e.g., through an FSR Menu). All audit functions should be easily accessible through a State/QA Menu.

- All data needed to determine audit results are clearly displayed and readily available to auditors.

ATP Development and Performance

To ensure that acceptance testing of the software includes all applicable functionality, a detailed acceptance test procedure (ATP) should be developed prior to the beginning of the actual testing process. An example of a detailed ATP for an ASM test system is provided in Appendix A. ATP development requires a thorough review of the equipment specifications to verify that all required functions will be checked. This review has the added benefit of identifying any inconsistencies or ambiguities in the specifications. These items can then be addressed in advance, thus avoiding a situation in which these types of problems are not identified until the test systems are delivered for acceptance testing. This leaves the program and manufacturers scrambling at the last minute to address these items, which often carry over into the rollout of the program.

The ATP is typically divided into the following four sections as shown in the example in Appendix A:

1. Main menu checks,
2. Inspection menu checks,
3. Test procedure scenarios, and
4. Additional checks.

In addition, sheets with the emissions test conditions, timers are also included as checks that should take place with the scenarios. These checks make sure that items such as checking for sample dilution are working properly and allow for the test to behave as per the specificaitons.

Acceptance testing of the software would begin with an evaluation of the Main menu elements, and then continue with checks of the Inspection menu elements. After the menu checks, multiple simulations of the individual test procedures (e.g., ASM, idle, and 2500 RPM emission tests) would be conducted following the applicable procedures contained in the ATP. These checks should include the use of simulated vehicle emissions and an RPM simulator, as appropriate. (This latter device was described in more detail in Section 2.)

The logic of how the test system should react in specific circumstances will be determined in advance and documented (see example in Appendix A). Defects should be identified and noted whenever the system response is inconsistent with the proper results for a particular set of inputs as specified in the ATP. An example bug log is provided in Appendix A. This allows a quantitative comparison of expected versus actual performance in each area of functionality. Various test simulations should be *incorporated into the test scenarios included in the ATP in order to fully check the* operation of the software.

Other performance assessments, or additional checks, should be conducted on the test system on a "random" basis at various points in the ATP. These checks include a variety of evaluation elements designed to ensure that the test system properly performs all non-inspection-related functions.

Beta Testing

While a comprehensive acceptance testing process typically results in the elimination of most software bugs, it is impossible to test all possible vehicle and test procedure combinations during this process. Therefore, another critical QA/QC pre-program element is *subjecting all test systems to a well-designed and thorough beta testing* process. Typically, this involves rolling the equipment out to a limited number of test stations following the successful completion of acceptance testing in a laboratory setting for additional testing using actual, privately owned vehicles. Beta testing is usually conducted by private repair shops whose owners have reached an agreement with the individual manufacturers to be a beta test site.

The repair shops use the beta version of the manufacturer's equipment, following the inspection procedures programmed into the equipment, to test vehicles that come to their facilities for I/M testing. Ideally, such testing would be performed for a sufficient minimum period of time (e.g., 30 days) to identify any additional bugs. In addition, the software should meet an established acceptance protocol before being allowed out of beta testing. This protocol could include such things as a minimum number of tests that are to be performed, the required correction and retesting of all bugs that are identified during

beta testing, a certain minimum number of "clean" tests (tests with no bugs in the software and no data record defects) after correction of all bugs, etc.

Prior to beta testing, procedures should be developed for mechanics at the beta sites to follow in conducting tests and noting and reporting potential equipment defects. These procedures should include a standard reporting form to use in documenting the details of each incident (an example beta testing bug log is provided in Appendix A). The beta-site mechanics would then be trained in properly following reporting procedures and filling out the reporting forms. Program staff or their contractor would observe initial testing at the beta sites, and assist mechanics in understanding the beta systems and reporting potential bugs.

The equipment manufacturers normally provide primary training to beta test mechanics on how to operate their test systems. The program staff/contractor's role in this area would therefore be limited to ensuring full documentation of the manner in which the equipment was operated that resulted in a potential bug. This should include observing testing, performing frequent audits of the equipment to ensure that the systems meet all required specifications during the beta period, collecting and reviewing test data, and collecting and reviewing any reporting forms completed by the beta sites. Efforts would also be undertaken if needed to duplicate and better document bugs initially identified by beta sites using test systems installed at the program's or contractor's laboratory. Experience has shown this to be needed in many cases because the beta sites cannot document or remember how a particular bug was generated.

While there are many areas of performance that should be evaluated during beta testing, one that is often overlooked is analyzing the data files being produced by the test systems to verify that they comply with all format and content specifications. This may seem like a fairly minor issue when a program is attempting to roll out a new enhanced test program. However, if this issue is not addressed at this time, it may well be discovered months into the program that there are significant problems with the data that are being generated, making all the data that have been generated to that point in time virtually useless. This is another instance in which the need to spend significant effort correcting problems in the future could have been prevented with a little extra effort in the beginning of the program.

Required Resources and Time

The above descriptions clearly show that a significant acceptance and beta testing effort is needed to properly roll out a program. It is anticipated that many programs would indicate they have neither the resources nor the time to spend on this level of testing prior to rollout. Unfortunately, recent experience across the country in rolling out enhanced programs (particularly those with decentralized networks) has shown that if this level of effort is not spent initially, even more time will need to be spent after the program is rolled out to correct problems that could have been avoided. Any defects in the test systems will come out eventually, and it is much easier to deal with these before testing hundreds of thousands or millions of vehicles with the equipment.

Sierra sees two basic factors that are driving states to roll out programs before they are ready. The first is that most states view their SIP obligations and milestone dates (for starting an enhanced program) as deadlines that must be met no matter what the cost. One of the best things that EPA could do in this regard would be to develop a reasonable policy and guidance on how it intends to work with states to give them the time they need to ensure that the test equipment is operating properly prior to rollout. (Obviously, this would require states to be making a good faith effort to implement an effective program.) This would result in the rollout of better operating programs, which would therefore be subject to less adverse public pressure. It would also help ensure that vehicles are being properly tested in these programs.

The second factor is that the states have settled for (and EPA has allowed) fairly limited acceptance testing of equipment in the past, which in hindsight was inadequate to identify and address all the problems in the test systems. The result has been several programs that have gone through the motions of acceptance testing while doing little to actually identify and correct both hardware and software problems. This is not meant to be overly critical of most states; for the most part, their intentions have been good. However, their staff have limited experience in understanding and conducting testing on enhanced emissions inspection systems. In many instances, the states have relied on contractors to perform such testing, who unfortunately have done a less than thorough job.

Testing of Non-BAR97 Equipment

While the above description paints a fairly bleak picture of past acceptance testing efforts, we do not see the situation improving in the future. If anything, it is likely to worsen due to further penetration of VMAS-based and other similar non-certified test systems into existing I/M programs. EPA is allowing states to develop and implement such customized systems with little oversight. As a result, programs are being rolled out that incorporate test systems that have not been subjected to thorough development and testing. As a result, there are I/M programs operating with what we believe are serious flaws in the enhanced emissions test systems.

We recognize that EPA (like the states themselves) has limited resources to address this issue. It is believed, however, that the Agency should hold the states to a much higher performance threshold than currently exists for testing and verifying the operation of new prototype systems prior to allowing their use. This recommendation fits well with the previous one regarding the development of guidance on how EPA will work with states to give them the time they need to ensure that the test equipment is operating properly prior to rollout. Combining a more stringent acceptance threshold with the possible granting of additional time to ensure test systems meet that threshold would clearly send the signal that these systems need to be operating properly prior to the start of a program. This in turn would give equipment manufacturers and contractors the message that they need to do a better job in ensuring fully functional systems.

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4. AUDITOR TRAINING COURSE

Audit procedures for all of the components in ASM and VMAS-based decentralized test systems were described in the audit guidance submitted to EPA under Work Assignment 2-05. For the current Work Assignment, Sierra has prepared a classroom training course to be used to train auditors. The goal of the training is to familiarize the auditors with the test systems, the audit procedures, and the types of failures that may be experienced. Participants in the training course should be provided a copy of the training presentation materials attached in Appendix B and a copy of the Work Assignment 2-05 audit procedures and forms.

The ideal training program would be divided into three parts designed to be conducted over two days. Part 1 would include a four-hour classroom session discussing the tests systems, acceptance testing, audit procedures, audit equipment, and common audit failures. Training materials for this portion of the training are included in Appendix B. Part 2 would be a four-hour hands-on training session with an ASM and/or VMAS-based decentralized test system (as appropriate) in a laboratory environment. This portion of the training should be conducted using the audit guidance developed under WA 2-05. To reinforce what was learned in the classroom and practiced in the lab, the last portion of the training should include actual field experience working with auditors conducting audits on actual decentralized test systems in a shop environment. This would provide experience in the practical and logistical issues related to performing equipment audits

Classroom Training Description

As mentioned above, the presentation materials for Part 1 (the classroom portion) of the training course are provided in Appendix B. The training materials begin with a general overview of the issues in QA/QC, ATP, calibration, performing audits in the field, audit menus on the various test systems, required audit equipment including audit vehicles, a discussion of record-keeping issues, and issues related to retesting failed test systems After the general overview, each test system area to be audited (as per the audit guidance) is discussed. These include the following·

1 Test system visual inspection,
2. Weather station,
3. Gas benches (NDIR for HC, CO, CO_2, and electrochemical NO cells),
4 Tachometer,
5 Dynamometer (steady state and transient testing),
6. Gas cap tester,
7. Pressure tester,

8. *OBDII scan tool software, and*
9. VMAS unit.

For each audit procedure, each of the following five areas is discussed:

1. Test system component operation,
2. Audit procedure for the component,
3. Audit tolerances,
4. Equipment required to perform the audit, and
5. Audit failures.

Test System Component Operation - The first item is a brief review of the theory of operation for each test system component to be audited. The training materials are not designed to make students experts in how the equipment works, but rather to provide the background needed to understand problems that are encountered during the audits and to understand the pass/fail criteria. The benefits and limitations of each test technology are also be discussed.

Audit Procedure for Each Component - The next area covered in the training is the development of the individual audit procedures for each audit component. The step-by-step procedures are covered along with the reasoning behind the procedures. There are subtleties for many of the procedures that are stressed in the procedures because if not followed, they could lead to inaccurate audit results.

Audit Tolerances - This area covers how the audit tolerances were developed for each procedure. The pass/fail criteria contained in the audit materials are based on the contents of EPA's latest guidance documents on enhanced emissions testing—i.e., the July 1996 version of the ASM test guidance and the April 2000 version of the IM240 and Evap Technical Guidance. In cases where the EPA documents did not provide guidance regarding relevant pass/fail criteria, the presentation covers how they were developed based on other available materials (e.g., the BAR97 specifications) or through discussions with knowledgeable stakeholders. For example, as noted in the previous section, Sensors was contacted for its input regarding appropriate audit procedures for the VMAS unit. In many IM programs, however, there is debate amongst the parties involved (state government, equipment vendors, and/or contractors) as to the appropriate level of stringency for audit tolerances. The presentation covers the development of each audit tolerance in the audit procedures, the basis of each, and the vendors' concerns.

Equipment Required to Perform the Audits - The training will cover the recommended test equipment for performing the audits. Potential suppliers and approximate costs for all of the required equipment are included in Section 3 of this report. The training will review the required equipment and calibration of the audit equipment, and present the approximate costs.

Audit Failures - The last portion of the training includes a discussion of the common failures of each test system component This portion of the training is also covered in detail in Section 2 of this report. Information from audits performed on operating IM

program test systems are presented to demonstrate problems found in the field. Insights into the types of equipment failures that are the most common, the impact of those types of failures on test accuracy, and what is being done by states and equipment vendors to resolve the problems will also be presented.

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APPENDIX A.
EXAMPLE ACCEPTANCE TESTING PROCEDURE

ANALYZER TOP LEVEL MENUS

MENUS SELECTION	PASS	CHECKS
Power on Self Test		
		disconnect keyboard, fails POST
		all connected passes
Calibrations Required?		requires calibration
gas bench HC CO NO zero span mid span		gas bench calibration lockout set/clear
leak check		leak check lockout set/clear
gas cap tester		gas cap tester calibration lockout set/clear
dynamometer warm up time		dynamometer warm-up lockout set/clear
dynamometer coast down		dynamometer coast down lockout set/clear
dynamometer load cell calibration		dynamometer load cell calibration
bench cal time		72 hours
dyno cal time		72 hours
TOP LEVEL MENU		
Menus Selection		
1) *Vehicle Inspection Menu (V)*		*all items presented*
2) Additional Site Specific Software (A)		single letter chooses menu
3) Diagnostic Functions (D)		secure access to state menu, not even to technician
4) Station Menu (s)		secure access to manufacturer's menu
5) NJ State Menu (N)		secure access state only
6) Manufacturer's Technician Menu (T)		secure access, service only
VEHICLE INSPECTION MENU		
1) Vehicle Inspection Menu		
1 Vehicle Emissions Inspection		see separate worksheet
2 Analyzer Maintenance		
(1) Three Day Gas Calibration		scan bottle values
(dyno coast down gas cal leak check)		manual entry of bottle values
		easy prompts, display results
		gas calibration fail sets lockout
		leak check fail sets lockout
		coast down fail sets lockout (8 to 18 hp, 2 settings)
		clear lockouts once passed
(2) Leak Check Only		clear lockouts once passed
(3) Gas Calibration Only		clear lockouts once passed
(4) Status Screen		all required data is displayed and is correct
(5) Dynamometer Calibration Only		clear lockouts once passed, +/- 7% of CCDT
(6) Pressure Test and Gas Cap Test Calibration		clear lockouts once passed
(7) Dynamometer Roll Speed Check		clear lockouts once passed +/- 0 2 mph, weekly
(99) Return to Main Menu		returns to inspection menu
3 Search and Reprint report/VIR		search by VIN, date and/or TIN
		review and print selected inspection record
		print "replacement VIR" with note duplicate and date of printing
		returns to inspection menu
4 Training Mode		"Training Mode" on VIR result is "T" TIN says "void" and "VOID" on VIR
		no test results on VIR
		no VID communications no EIS DAT generated
		returns to inspection menu
99 Return to Main Menu		returns to Main menu
2) Additional Site Specific Software		optional, dial up access to diagnostic data base, etc (may not be installed)
		verify no access to State emissions testing program
		verify no access to operating system/ file structure
3) Diagnostic Functions		manual testing and repair functions, not accessible from within official emissions tests
		verify no access to State emissions testing program
		verify no access to operating system/ file structure
4) Station Menu		
1 *Network Communication Diagnostics*		*modem serial port diagnostics*
		dial tone check
		network diagnostics
2 Data File Refresh		refresh date and time AUDITOR DAT TECH DAT FUEL DAT LOCKOUT DAT INSPCOND DAT SPD2 DAT ASMSTDS DAT NEWSTDS DAT DEFPRAM DAT, SYSTEM DAT
		note updated, or cannot access network
3 Lockout Status Refresh		contact VID request LOCKOUT DAT show status or cannot access network
4 Print a Communications Log		print listing of past 14 days or last 100 sessions
		prompt for number of sessions to be printed
5) NJ State Menu		scan inspector badge input access code after three attempts back :o Main menu
1 State Analyzer Maintenance		
(1) Three Day Gas Calibration		scan bottle values
(dyno coast down gas cal, leak check)		manual entry of bottle values
		easy prompts display results
		gas calibration
		leak check
		coast down 8 to 18 hp random 2 settings
(2) *Leak Check Only*		*leak check*
(3) Gas Calibration Only		gas calibration
(4) Status Screen		all required data is displayed and is correct
(5) Dynamometer Calibration Only		+/- 7% of CCDT
(6) Pressure Test and Gas Cap Test Calibration		test gas cap only
(7) Dynamometer *Roll Speed Check*		+/- 0 2 mph
(99) Return to State Menu		returns to State menu
2 Gas Audit		no preset values display in large characters and print results
3 Update Station Information		display all information in STATION DAT and allow to be changed log to audit file
4 Install New Data Disk		replace secured floppy diskette format, copy previous records
		when complete return to State menu
5 Practical/Demo Test Record		same as Inspection menu
6 Lockout Functions		display lockouts
		allow lockouts to be changed
		transfer lockout changes to VID
7 Perform Emergency Software Update		changes software version number returns to NJ State menu or reboot
8 Test Record Search and Retrieval		same as Inspection menu saves to floppy
9 Total Number of Inspections Since Last Data Transfer		display number prompt to return to NJ State menu
99 Return to Main Menu		return to Main menu
6) Manufacturer's Technician Menu		manufacturer to propose security method writes to audit file

INSPECTION ITEMS

Reference	Function	NOTES	Pass	CERTIFICATION TESTING REQUIRED	Field Name (EIS DAT)	No
VEHICLE INSPECTION MENU						
pg 33 3 3 A 1	1 Vehicle Inspection 2 Analyzer Maintenance 3 Search and Reprint Report/VIR 4 Training Mode 99 Return to Main Menu Select Option Desired Enter Number ____	access code required		all menu items presented		
pg 34 + 35 3 3 B 1	Vehicle Selected Lockouts Set?					
	State lockout set at machine			VID cannot set/ clear		
	Cabinet tampering			set at machine, cleared by VID or in person		
	Station license has been revoked or suspended			set by VID cleared by VID or in person		
	Station license has expired			set by VID cleared by VID or in person		
	Failure to pay for communications services			set by VID cleared by VID or in person		
	Max offline tests exceeded	number of days from VID		set by VID cleared by VID or in person		
	Corrupt data file or other problem			set at machine cleared by VID or in person		
pg 35 3 3 B 3	Aborts	do not write INCOMPLT DAT before ID entered		abort does not write INCOMPLT DAT		
pg 35 3 3 B 3	Inspector Access (Manual or Bar-code)	three tries or back to main menu double blind if manual		manual entry of invalid license prompt not a valid license back to main menu	Check in TECH DAT	
		license in TECH DAT		manual entry valid license valid access code	Software Version	4
		license access code matches		bar code entry, access code valid	License Number	5
		license has not expired		license expired prompt license expired back to main menu	Input Source	6
					Test Record Number	1
pg 35 3 3 B 3	Aborts	write INCOMPLT DAT after ID entered		abort writes INCOMPLT DAT (for each inspector) from this point forward	*INCOMPLT DAT*	
pg 36 3 3 B 3 C	Inspector Exist in INCOMPLT DAT Y/N?,	If a file for the inspector not present create a file		add inspector to INCOMPLT DAT as required	Facility ID	2
				increment test started field in incompit dat	Analyzer Number	3
				increment test aborted field if test ends prior	Test Date	37
				to record write to EIS DAT on hard drive	Test Start Time (24 hour time)	38
				date change creates new record sends old records		
				print VIR with "Invalid " next to pollutant readings		
pg 36 3 3 B 4	VIN Entry	bar code vehicle or manual entry? B/V/M?		cannot cut and paste to do double blind	VIN	8
		2nd manual entry match? Y/N?		manual entry double blind pass	VIN source	9
				DMV renewal form bar code entry		
				read bar code on vehicle		
pg 37 3 3 B 4	Jurisdiction Entry	no prompts if scanned		pick from list	License plate jurisdiction	11
		show list of all 50 states				
pg 38 3 3 B 4	Sticker Expiration Entry	no prompts if scanned		manual entry	Old sticker date	148
		MM/YYYY format		blank will not proceed		
		do not proceed until entered		wrong format, will not accept		
pg 37 3 3 B 4	License Plate Entry	no prompts if scanned if manual then double blind		manual entry	Plate no	10
		only manual entry do not proceed until entered		blank, will not proceed	Plate Source	12
pg 37 3 3 B 5	Select Test Type	Initial / Reinspection		initial test go to network communications	Test type (initial/retest)	36
		reinspection ask about repairs		reinspection no entry back to first prompt		
		ask for repair info		reinspection no repair data go to network communications		
		display cost categories		reinspection repair data		
		repair categories and codes mfg interface <9		reinspection, repair data enter repair facility ID	Emission repair facility number	REPAIR DAT 15
		parts and labor costs no decimals < 9999		reinspection repair data enter repair technician ID	Emission repair technician ID	REPAIR DAT 14
				reinspection repair data do not enter date show error message		
				reinspection repair data enter date	Repair date	REPAIR DAT 11
				reinspection repair data enter parts costs >9999, show error message		
				reinspection, repair data enter parts costs with cents		
				reinspection, repair data enter valid parts cost if cents not accepted	Parts total	REPAIR DAT 16
				reinspection repair data enter labor costs >9999 show error message		
				reinspection, repair data enter labor costs with cents		
				reinspection repair data enter valid labor cost if cents not accepted	Labor total	REPAIR DAT 17
				reinspection repair data enter category 27 show error message		
				reinspection repair data enter > 9 valid repair categories and codes		
				reinspection repair data enter < 9 valid repair categories and codes	Repair codes	REPAIR DAT 12
				reinspection, repair data enter code 99		
				reinspection repair data enter work order number	Work order number	REPAIR DAT 18
				reinspection repair data Y-additional forms return to prompt III write file		
				reinspection, repair data no more forms go to network communications		
pg 38 3 3 B 5	Pink Card Entry			request pink card date be entered enter future date get error message	Inspection Allowance Date (IAD)	152
				enter a valid date (today or older) continue		

INSPECTION ITEMS

Reference	Function	NOTES	Pass	CERTIFICATION TESTING REQUIRED	Field Name (EIS DAT)	No
pg 40 3 3 B 6	Network Connection	display prompt that system is connecting to network		45 seconds no connection redial	Number of days/tests allowed w/o cont	
		if no connection prompt proceeding with inspection		second attempt no connection proceed with inspection as "no match" prompt		
				no dial tone?		
				ANI not validated display message		
				incorrect token warning prompt test continues		
pg 29 2 25 d) 2		Write INCOMPLT DAT		inspector license expired abort	*INCOMPLT DAT*	
pg 29 2 25 d) 2		Write INCOMPLT DAT		inspector license revoked abort	*INCOMPLT DAT*	
pg 29 2 25 d) 2		Write INCOMPLT DAT		inspector license invalid abort	*INCOMPLT DAT*	
				everything validated works		
pg 41 3 3 B 6 B	Network Access (transmitted data)			VIN		
				license plate		
				NJ1 Indicator		
				punk card indicator		
				records (EIS CAL AUDIT REPAIR INCOMPLT SECxSEC)		
				current lockout status		
				VRT DAT and ASMSTDS DAT version date		
pg 41 3 3 B 6 C	Network Access (no match)	if vehicle match is found no changes allowed to		NJ licensed no-match first try ask for VIN and plate re-entry no changes manual entry		
		VIN and license abort if required		NJ licensed no-match first try VIN re-entry change, second no match proceed		
				NJ licensed no-match first try VIN re entry, change to valid VIN		
		look in EIS DAT or EIS DAT		no comm search EIS DAT and EIS HST for VIN not found prompt N abort		
		not in EIS files verify VIN		no comm search EIS DAT and EIS HST for VIN not found prompt, Y proceed		
				no comm search EIS DAT and EIS HST for VIN found proceed		
pg 43 3 3 B 6 D	Network Access (received data)	refer to communications specs		receive Vehicle Data	VID vehicle ID	27
				receive TSB and Recall Information	Previous cycle initial odometer	33
				receive System Date/Time Update	Previous cycle initial test date	34
				receive Lockout Status		
				receive Inspector and Auditor Data (TECH DAT and AUDITOR DAT)		
				receive DMV Messages		
				received Program Data (SYSTEM DAT)		
				receive Updates to the Vehicle Reference Table (VRT DAT)		
				receive Two Speed Idle Emissions Table (SPD2 DAT)		
				receive Updates to ASM Emissions Table (ASMSTDS DAT)		
				check applicability of NEWSTDS DAT by copy date in SYSTEM DAT if NEWSTDS DAT exist		
				and date pasted, delete ASMSTDS DAT rename NEWSTDS DAT to ASMSTDS DAT		
				received Horsepower Default Table (DEFPRAM DAT)		
pg 43 3 3 B 6 E	Display Data Fields	allow for changes		display 13 vehicle data fields and allow for changes		
		more than 45 days since last faded test		prompt that a full reinspection must be performed		
pg 45 3 3 B 6 F	Initial versus Retest Check	if initial found previous test ask if change to retest		type entered is initial VID sends back retest, prompt for retest (Y/N?) change to retes	Test type (initial or retest)	38
				type entered is initial VID sends back retest prompt for retest (Y/N?) keep initial		
pg 45 3 3 B 6 G	Recall Notice and TSB Information	display and allow to print		display recall or TSB info		
				print recall or TSB info		
pg 46 3 3 B 7	Vehicle Review Screen			display 11	Model year	13
				prompt to enter missing data	Make	14
pg 22 2 3		model year not < 1900 or > current + 2		change model year to 1899 show prompt	Model	15
				change model year to 2005 show prompt	Trans type	24
				prompt to verify fuel code show list GASO highlighted	Vehicle type	16
				prompt to enter fuel code enters wrong code shows error message returns to promp	Body style	17
				prompt to enter fuel code enters bi-fuel code prompt to test on gasoline	Cert class	18
				prompt to enter fuel code enters exempt from testing code prompt to do safety	Fuel code	26
				prompt to enter cert class give message and allowed values	Number of cylinders	22
				prompt to check transmission type if E (only A and M allowed)	Engine size	23
				prompt to enter certification class give message on allowed values and how to determine		
pg 47 3 3 B 8	GVWR Entry	manual entry		no value entered should not accept	GVWR	19
		> 8 500 pounds receives an idle test		enter 1999 pounds should not accept, give error message	ETW	20
				enter 80001 pounds should not accept give error message	ETW Source	21
				decimal point entered		
				valid reading entered if decimal point not accepted		
pg 47 3 3 B 8	Odometer Reading	calculate if low mileage exemption applies		no value entered should not accept	Odometer Reading	32
				decimal point entered		
				valid reading entered if decimal point not entered		
pg 48 3 3 B 8	Dual Exhaust Y/N?	only Y or N for answer accepted		no value entered, should not accept	Dual Exhaust	25
				enter "M" should not accept		
				valid reading entered if decimal point not entered		
pg 48 3 3 B 9 1	VRT Lookup Row ID			find VRT match	VRT Record No	28
				no VRT match use DEFPARM DAT	ASMSTDS DAT record number	29
pg 49 3 3 B 10	WRITE PRELIMINARY EIS DAT	Write all previous fields				

INSPECTION ITEMS

Reference	Function	NOTES	Pass	CERTIFICATION TESTING REQUIRED	Field Name (EIS DAT)	No
pg 51 3 3 B 11 B	Credentials Check	"Finished?" default is "N" "P" replaces previous conditions initial test conditions all default to P else old result finished filed defaults to "N"		enter N or X for each item, see if correct inspection conditions are shown select no condition display prompt to return to item enter "N" stay on prompt select no condition display prompt to return to item enter "Y" return to item screen check inspection conditions logic for pass, fail with P N and X with A F or 4 at bottom under "Finished?" enter N should stay on screen at bottom under "Finished?" enter Y go to next check even with previous test Credentials results always default to blank	Credentials result	110
pg 52 3 3 B 11 B	Steering/Suspension Check	"Finished?" default is "N" "P" replaces previous conditions initial test conditions all default to P else old result finished filed defaults to "N"		enter N or X for each item see if correct inspection conditions are shown select no condition display prompt to return to item enter "N" stay on prompt select no condition display prompt to return to item enter "Y" return to item screen check inspection conditions logic for pass fail with P N and X with A F or 5 at bottom under "Finished?" enter N should stay on screen at bottom under "Finished?" enter Y, go to next check	Steering and suspension result	111
pg 52 3 3 B 11 B	Safety Equipment Check	"Finished?" default is "N" "P" replaces previous conditions initial test conditions all default to P else old result finished filed defaults to "N"		enter N or X for each item see if correct inspection conditions are shown select no condition, display prompt to return to item enter "N" stay on prompt select no condition display prompt to return to item enter "Y" return to item screen check inspection conditions logic for pass, fail with P N and X with A F or 6 at bottom under "Finished?" enter N, should stay on screen at bottom under "Finished?" enter Y go to next check	Safety Equipment result	112
pg 52 3 3 B 11 B	Lights Check	"Finished?" default is "N" "P" replaces previous conditions initial test, conditions all default to P else old result finished filed defaults to "N"		enter N or X for each item see if correct inspection conditions are shown select no condition, display prompt to return to item enter "N" stay on prompt select no condition, display prompt to return to item enter "Y" return to item screen check inspection conditions logic for pass fail with P N and X with A F or 7 at bottom under "Finished?" enter N, should stay on screen at bottom under "Finished?" enter Y, go to next check	Lights result	113
pg 52 3 3 B 11 B	Brakes Check	"Finished?" default is "N" "P" replaces previous conditions initial test conditions all default to P else old result finished filed defaults to "N"		enter N or X for each item see if correct inspection conditions are shown select no condition display prompt to return to item enter "N" stay on prompt select no condition display prompt to return to item enter "Y" return to item screen check inspection conditions logic for pass fail with P N and X with A F or 8 at bottom under "Finished?" enter N should stay on screen at bottom under "Finished?" enter Y go to next check	Brakes result	114
pg 53 3 3 B 11 B	Exhaust Check	"Finished?" default is "N" "P" replaces previous conditions initial test conditions all default to P else old result finished filed defaults to "N"		enter N or X for each item, see if correct inspection conditions are shown select no condition, display prompt to return to item enter "N" stay on prompt select no condition display prompt to return to item enter "Y" return to item screen check inspection conditions logic for pass fail with P N and X with A F or 9 at bottom under "Finished?" enter N should stay on screen at bottom under "Finished?" enter Y go to next check	Exhaust system result	115
pg 53 3 3 B 11 B	Miscellaneous Check	"Finished?" default is "N" "P" replaces previous conditions initial test conditions all default to P else old result finished filed defaults to "N"		enter N or X for each item see if correct inspection conditions are shown select no condition display prompt to return to item, enter "N" stay on prompt select no condition display prompt to return to item enter "Y" return to item screen check inspection conditions logic for pass fail with P N and X with A F or 10 at bottom under "Finished?" enter N, should stay on screen at bottom under "Finished?" enter Y go to next check	Miscellaneous items result Miscellaneous comment Miscellaneous comment result	116 117 118
pg 54 3 3 B 11 C	Overall Safety Test Result	can only be P or F		displays overall pass fail result, only P or F	Overall safety result	119
pg 56 3 3 B 12	Visual Anti-Tampering Inspection	can only be P or F		originally equipped no exit originally equipped yes prompt to check	Catalytic Converter Inspection Result	106
pg 56 3 3 B 13 B	Gas Cap Pressure Test			cap Accessible? No prompt to fail answer no to fail yes to question can cap be removed? No prompt to fail answer no to fail yes to question does the Gas cap fit an adapter? No passes does the Gas cap fit an adapter? Yes proceed with test test cap fail prompt to replace say no prompt will fail answer replace prompt to replace and repeat test pass prompt "More than one fuel tank?"	 Adapter available Replaced during test Overall gas cap test results	 56 57 58
pg 58 3 3 B 13 C	Tank Pressure Test			to be tested at a later date	Pressure test result	104
pg 59 3 3 B 14 A	Retest?			If retest and passed emissions test previously display question if to retest (Y/N)		
pg 59 3 3 B 14 B	Retest Waiver			if previously received an exhaust waiver from a CIF ask if emissions test retest (Y/N)		
pg 60 3 3 B 14 D	Emissions Test Selection	optional idle test		prior to startup date (DEC 10) for ASM qualified vehicles ask if want idle test		
pg 61 3 3 B 14 D 3	For ASM, Check Dyno Testable	for ASM indicated check if dyno testable		ask if 4WD or AWD can not be disengaged if yes prompt for reason	Reason for non-dyn testable Dyno Testable	30 31
pg 62 3 3 B 14 D 4	Low Mileage Vehicle Exemption	no pink card or previous odometer		ask if motorist want to claim low mileage yes ask mileage in last two years mileage greater than 10 000 prompt that they are ineligible	Low mileage exemption	42

INSPECTION ITEMS

Reference	Function	NOTES	Pass	CERTIFICATION TESTING REQUIRED	Field Name (EIS DAT)	No
pg 63 3 3 B 14 E 1	Zero Air			no zero air pressure fail		
				zero air not "zero"		
				flow clean air pass		
pg 63 3 3 B 14 E 1	Ambient			ambient air fails (> 15 ppm HC 0 02% CO or 25 ppm NO)	Relative Humidity	46
				ambient air passes	Humidity correction factor	49
pg 66 3 3 B 14 F 2 c				heat temperature sensor warm ambient temperature out of range check sensor	Ambient Temperature	47
					Barometric Pressure	48
pg 63 3 3 B 14 E 2	HC Hang-up Check			HC hang-up check fails (probe - ambient > 7 ppm HC)		
				HC hang up check passes		
pg 678 3 3 B 14 G	Request RPM Pickup Type	should request OBDII if 1996+		contact/non contact/OBDII		
				RPM unstable request change method of measurement		
				RPM unstable three times allow bypass	RPM bypass	122
				RPM stable okay		
pg 68 3 3 B 14 H	Emissions Test (ASM, 2500 or Idle)			ASM test scripts	Emissions test type (performed)	40
				if ASM 5015 was tire drying used?	Tire drying	43
pg 76 3 3 B 14 I				2500 RPM test scripts		
pg 76 3 3 B 14 I				idle test scripts	Exhaust emission result	102
pg 35 3 3 B 3	Aborts	aborts not allowed after emissions test		attempt to abort abort not allowed		
pg 63 3 3 B 15	Visible Smoke Check	anytime during test		yes or no if smoked for more than 3 seconds	Visible smoke test result	103
		rev engine for three seconds and look for smoke		if no prompt to increase RPM to above idle for three seconds prompt if smoked yes or no		
pg 84 3 3 B 16 A	Overall Emissions Test Result				Overall Emission Result	108
pg 84 3 3 B 16 B	Overall Safety Test Result				Overall Safety Result (also given abo	119
pg 84 3 3 B 16 C	Overall Test Result				Overall test result	120
pg 85 3 3 B 17	Print VIR			request enter sticker number if result is pass otherwise do not display	Sticker number	124
				request enter test fee	Test fee	123
pg 126 5 1 [72] F	Sticker Number (Passes Only)			set flag in SYSTEM DAT to yes prompt to confirm change to 2 months invalid	Certificate number	125
				change to 27 months invalid	Sticker date - Calculated	154
				change to 14 months accept	Sticker date - Actual	155
				change flag in SYSTEM DAT no prompt to confirm date	Sticker date overridden?	126
Pg 152 Append E	Calculate TIN			use formula and example code given in spec (12261952)	TIN	44
pg 79 3 3 B 18	Print VIR			printer failure (remove cable) correct	Test end time	39
pg118 5 1				printer failure unable to correct (prompt to retry to print) prompt to consumer about test		
				check VIRs for correct information		

ASM/2500 RPM/IDLE TEST SCENARIOS															
Test Type	Options	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Retest	I/R				X		X				X				X
Waiver return	Y/N														
Model year	pre 71 71-74, 75-80, 81+	pre 68	pre 68	68-70	68-70	71-74	71-74	71-74	71-74	75-80	75-80	75-80	75-80	81+	81+
Low mileage exemption	Y/N														
Over 8500 GVWR	Y/N							X				X			
AWD/4WD non-disengagable	Y/N														
Fuel type	GASO, GCNG, PROP								X				X		
84 BMW, auto	Y/N														
92 Peugeot 505 auto	Y/N														
83 Volvo 740, auto	Y/N														
ASM														X	?
2500															
idle		X	X	X	X	X	?	X		X	?	X			
Gas cap						X	?	X	X	X	?	X	X	X	?
Pressure														X	?
Cat inspection										X	?	X	X	X	?
Safety		X	X	X	?	X	?	X	X	X	?	X	X	X	?
Vehicle Identification															
VIN entry		099	100	101	101	102	102	103	104	105	105	106A	107	108	108
Jurisdiction	NJ, other	NJ	NJ	NJ	NJ	Guam	Guam	NJ	NJ	NJ	NJ	NJ	CA	NJ	NJ
Sticker expiration		#NAME?	#NAME?	#NAME?	#NAME?			#NAME?	#NAME?	#NAME?	#NAME?	#NAME?		#######	#######
Plate number		TST1	TST2	TST3	TST3	TST4	TST4	TST5	TST6	TST7	TST7	TST8	TST9	TST10	TST10
Test type (Initial or reinspection)	I, R	I	I	I	R	I	R	I	I	I	R	I	I	I	R
Pink card? Enter date (use as IAD)	MM/YYYY		24-May			4-Jun	3-Jun								
Vehicle type	P, T, H	P	T	P	P	P	T	H	P	P	P	H	T	T	T
GVWR	1 (<6K), 2, 3 (>8 5K)	1	2	1	1	2	2	3	1	1	1	3	1	1	1
Cert class	-, Tier I, LEV,														
Model year		55	65	70	70	72	72	73	74	80	80	75	79	81	81
Make		CHEV	FORD	DODG	DODG	FORD	TOY	INTER	FORD	TOY	TOY	HUNK	CHEV	JEEP	JEEP
Model		BEL AIR	F150	CHALL	CHALL	MUST	CORN	BUBBA	TORIN	CRESS	CRESS	FT BOY	PRT VAN	WAGON	WAGON
Body style	1 - 6	1	4	1	1	1	4	N/A	2	2	2	N/A	6	4	4
Cylinders	1 - 16, R	8	8	8	8	6	4	8	8	6	6	8	8	6	6
Engine size	99 9 L	4 7	5 3	5 9	5 9	3	1 6	6 5	7 5	2 6	2 6	8	5	4 2	4 2
Transmission type	A, M	M	A	A	A	M	M	M	A	A	A	A	M	M	M
Test weight														4000	4000
Fuel code	GASO, GCNG, PROP	GASO	GASO	GASO	GASO	GASO	GASO	GASO	PROP	GASO	GASO	GASO	METH	GASO	GASO
Dual exhaust	Y, N	N	N	N	N	Y	Y	N	N	Y	Y	N	N	N	N
Dyno testable	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	Y
Reason for non-dyn testable	1, 2, 3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Claimed low mileage exemption, estimated mileage		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Current odometer		25000	33333	44444	55555	66666	77777	88888	99999	86666	84444	56666	54444	92222	93333
GVWR		4500	6600	4250	4250	3500	6500	9500	5500	5000	5000	12000	5500	4500	4500

ASM/2500 RPM/IDLE TEST SCENARIOS															
Test Type	**Options**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**
Retest	I/R														
Waiver return	Y/N	X													
Model year	pre 71 71-74 75-80, 81+	81+	81+	81+	81+	81+	81+	81+	81+	81+	81+	81+	81+	81+	81+
Low mileage exemption	Y/N		X												
Over 8500 GVWR	Y/N			X											
AWD/4WD non-disengagable	Y/N				X										
Fuel type	GASO, GCNG, PROP					X									
84 BMW, auto	Y/N						X								
92 Peugeot 505, auto	Y/N							X							
83 Volvo 740, auto	Y/N								X						
ASM										X	X	X	X	X	X
2500			X		X										
idle				X			X	X	X						
Gas cap		?	X	X	X	X	X	X	X	X	X	X	X	X	X
Pressure		?	X		X	X	X	X	X	X	X	X	X	X	X
Cat inspection		?	X	X	X	X	X	X	X	X	X	X	X	X	X
Safety		?	X	X	X	X	X	X	X	X	X	X	X	X	X
Vehicle Identification							These three, choose idle								
VIN entry		109	110	111	112	113	114	115	116	117	118	119	120	121	122
Jurisdiction	NJ, other	NJ	NJ	NJ	NJ	NJ	Oregon	NJ	NJ	other	NJ	NJ	NJ	NJ	NJ
Sticker expiration		#NAME?	#NAME?	######	#NAME?	#NAME?		######	#NAME?		#NAME?	#NAME?	######	#NAME?	#NAME?
Plate number		TST11	TST12	TST13	TST14	TST15	TST16	TST17	TST18	TST19	TST20	TST21	TST22	TST23	TST24
Test type (Initial or reinspection)	I, R	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Pink card? Enter date (use as IAD)	MM/YYYY		N		25-May	5/1/1999	16-Apr			2-Jun		16-May			10-May
Vehicle type	P, T, H	P	P	H	T	T	P	P	P	P	P	P	P	T	T
GVWR	1 (<6K), 2, 3 (>8 5K)	1	1	3	2	1	1	1	1	1	1	1	1	2	2
Cert class	-, Tier I, LEV,														
Model year		86	95	89	91	99	87	92	84	91	93	85	1	97	87
Make		AMC	GEO	HEAVY	FORD	DODG	BMW	Peugeot	Volvo	MAZ	BMW	CHEV	FORD	FORD	CHEV
Model		ALLIAN	METRO	TRUCK	RANG	PICKUP	3 SER	505	740	RX-7	7 SER	BEAST	WNDSTR	E250	R20 P/U
Body style	1 - 6	1	1	N/A	3	4	1	2	1	1	1	2	5	6	3
Cylinders	1 - 16, R	4	3	8	6	8	6	4	4	3R	8	8	6	8	8
Engine size	99 9 L	1 4	1	6 6	3	6	2 7	1 9	2 3	1 3	4	10	3 8	8	5 7
Transmission type	A, M	A	A	M	A	A	A	A	A	A	A	M	A	A	M
Test weight			2000		3625	4125	2625	3125	3125	3250	4250	4000	4125	7000	4500
Fuel code	GASO, GCNG, PROP	GASO	GASO	GASO	GASO	DIES	GASO	GASO	GASO	GASO	GASO	GASO	GASO	GASO	GASO
Dual exhaust	Y, N	Y	Y	Y	N	Y	Y	N	N	Y	N	N	N	N	N
Dyno testable	Y, N	N/A	N/A	N/A	N	N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y
Reason for non-dyn testable	1, 2, 3	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Claimed low mileage exemption, estimated mileage		N/A	Y	N/A	N/A	N/A	N	N	N	N/A	N/A	N/A	N/A	N/A	N/A
Current odometer		94444	95555	96666	97777	98888	99999	88888	77777	66666	55555	44444	33333	22222	100000
GVWR		300	2850	20000	5200	5800	3500	5300	5000	3750	3750	6000	5500	7000	6500

ASM/2500 RPM/IDLE TEST SCENARIOS															
Test Type	Options	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Vehicle Inspection Scenario Information	6/6/1999														
VID contact?	Y, N	Y	Y	Y	Y	N	Y	Y	N	Y	N	Y	Y	N	N
RID (incoming)	MM/DD/YYYY	######	7/1/1997	######	######	6/6/1999	6/3/1999	######	6/6/1999	######	6/6/1999	8/1/1997	6/3/1999	6/6/1999	6/6/1999
RID (outgoing)		######	7/1/1997	######	6/6/1999	6/6/1999	6/3/1999	6/6/1999	6/6/1999	6/6/1999	6/6/1999	8/1/1997	6/3/1999	6/6/1999	6/6/1999
IED (incoming)	MM/DD/YYYY	#NAME?	#NAME?	#NAME?	#NAME?	blank	6/3/1999	#NAME?	blank	#NAME?	blank	#NAME?	6/3/1999	blank	blank
IED (outgoing)		#NAME?	#NAME?	#NAME?	#NAME?	7/6/1999	6/3/1999	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	6/3/1999	######	#NAME?
ICD (incoming)	MM/DD/YYYY	#NAME?	#NAME?	#NAME?	#NAME?	blank	######	#NAME?	blank	#NAME?	blank	#NAME?	6/3/1999	blank	blank
ICD (outgoing)		#NAME?	#NAME?	#NAME?	#NAME?	7/6/1999	######	######	#NAME?	#NAME?	#NAME?	#NAME?	7/6/1999	#NAME?	#NAME?
ICD flag (coming in from VID)		Y	T	Y	N	Y	N	Y	Y	Y	N	Y	F	Y	N
ICD flag (going out)	N, Y, T, R, F	N	N	N	Y	N	N	Y	N	N	Y	N	N	Y	Y
IAD (incoming)			6/7/1999			blank	7/3/1999		blank		blank		7/3/1999	blank	blank
IAD (outgoing)			6/7/1999			blank	7/3/1999		blank		blank		7/3/1999	blank	blank
Credentials Check															
Driver license	P, F, A	P	P	P	Z	P	Z	P	P	P	Z	P	P	P	Z
Registration	P, F, A, 4	P	P	P	Z	F	F	P	P	P	Z	P	P	P	Z
Insurance documents	P, F, A, 4	P	P	P	P	F	P	P	P	P	Z	P	P	P	Z
Plates	P, F, A, 4	P	P	P	Z	P	Z	P	P	P	Z	P	P	P	Z
Other credentials	P, F, A, 4	P	P	F	Z	P	Z	P	P	P	Z	P	P	P	Z
Odometer	P, F, A, 4	P	P	P	Z	P	Z	P	P	P	Z	P	P	P	Z
Overall	P, F	P	P	F	P	F	F	P	P	P	Z	P	P	P	Z
Steering/Suspension Check															
Steering/suspension	P, F, A, 4	P	P	P	Z	P	P	P	F	P	Z	P	P	P	Z
Overall	P, F	P	P	P	Z	P	P	P	F	P	Z	P	P	P	Z
Safety Equipment Check															
Glass	P, F, A, 4	P	P	P	Z	P	Z	P	P	P	Z	P	P	P	Z
Horn	P, F, A, 4	P	P	P	Z	P	Z	P	P	P	Z	P	P	P	Z
Wipers	P, F, A, 4	P	P	P	Z	P	Z	P	P	P	Z	P	P	P	Z
Mirrors	P, F, A, 4	P	P	F	P	F	P	P	P	P	Z	P	P	P	Z
Tires/wheels	P, F, A, 4	P	P	P	Z	P	Z	P	P	P	Z	P	P	P	Z
Visual obstruction	P, F, A, 4	P	P	P	Z	P	Z	P	P	P	Z	F	P	P	Z
Overall	P, F	P	P	F	P	F	P	P	P	P	Z	F	P	P	Z
Lights Check															
Headlights	P, F, A, 4	P	P	P	Z	P	Z	P	F	P	Z	P	P	P	Z
Rear lights	P, F, A, 4	P	P	P	Z	P	Z	P	P	P	Z	P	P	P	Z
Turn/warning lights	P, F, A, 4	P	P	P	Z	P	Z	P	P	P	Z	P	P	P	Z
Plate lights	P, F, A, 4	P	F	P	Z	P	Z	P	P	P	Z	P	P	P	Z
Other lights	P, F, A, 4	P	P	P	Z	P	Z	P	P	P	Z	P	P	P	Z
Marker/clear/reflector	P, F, A, 4	P	P	P	Z	P	Z	P	P	P	Z	P	P	P	Z
Wiring/switches	P, F, A, 4	P	P	P	Z	F	P	P	P	P	Z	P	P	P	Z
Overall	P, F	P	F	P	Z	P	Z	P	F	P	Z	P	P	P	Z

ASM/2500 RPM/IDLE TEST SCENARIOS															
Test Type	Options	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Vehicle Inspection Scenario Information	6/6/1999														
VID contact?	Y, N	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	Y
RID (incoming)	MM/DD/YYYY	5/1/1997	#######	#######	#######	4/1/1999	#######	6/3/1997	6/6/1999	11/5/1995	6/9/1997	#######	6/6/1999	6/1/1997	########
RID (outgoing)		5/1/1997	6/6/1999	#######	#######	6/6/1999	6/6/1999	6/6/1999	6/6/1999	11/5/1995	6/9/1997	#######	6/6/1999	6/6/1999	########
IED (incoming)	MM/DD/YYYY	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#######	#######	blank	6/2/1999	#NAME?	#NAME?	blank	#NAME ?	#NAME?
IED (outgoing)		#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	6/2/1999	#NAME?	#NAME?	#######	#NAME ?	#NAME?
ICD (incoming)	MM/DD/YYYY	#NAME?	#NAME?	#######	#NAME?	#NAME?	#######	#######	blank	6/2/1999	#NAME?	#NAME?	blank	#NAME.?	#NAME?
ICD (outgoing)		#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	#NAME?	7/6/1999	#NAME?	#######	#NAME?	#NAME?	6/20/1999
ICD flag (coming in from VID)		Y	Y	Y	T	T	F	Y	Y	F	Y	T	Y	Y	T
ICD flag (going out)	N, Y, T, R, F	N	Y	N	N	Y	Y	Y	N	N	N	N	N	Y	N
IAD (incoming)					6/8/1999	#######	#######		blank	7/2/1999		#######	blank		5/24/1999
IAD (outgoing)					6/8/1999	#######	#######		blank	7/2/1999		#######	blank		5/24/1999
Credentials Check															
Driver license	P, F, A	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Registration	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Insurance documents	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Plates	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	F	P	P	P
Other credentials	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Odometer	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	P	P	P	F
Overall	P, F	P	P	P	P	P	P	P	P	P	P	F	P	P	F
Steering/Suspension Check															
Steering/suspension	P, F, A, 4	P	P	P	P	P	P	P	A	P	P	P	P	P	P
Overall	P, F	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Safety Equipment Check															
Glass	P, F, A, 4	P	P	F	P	P	P	P	P	P	P	P	P	P	P
Horn	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Wipers	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	F	P	P	P
Mirrors	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Tires/wheels	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Visual obstruction	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Overall	P, F	P	P	F	P	P	P	P	P	P	P	F	P	P	P
Lights Check															
Headlights	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Rear lights	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Turn/warning lights	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Plate lights	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Other lights	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Marker/clear/reflector	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Wiring/switches	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Overall	P, F	P	P	P	P	P	P	P	P	P	P	P	P	P	P

ASM/2500 RPM/IDLE TEST SCENARIOS															
Test Type	**Options**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Brakes Check															
Service brake	P, F, A, 4	P	P	4	P	P	Z	P	P	P	Z	P	P	P	Z
Parking brake	P, F, A, 4	P	P	F	P	P	Z	P	P	P	Z	P	P	P	Z
Brake equalization	P, F, A, 4	P	P	F	P	P	Z	P	P	P	Z	P	P	P	Z
Overall	P, F	P	P	F	P	P	Z	P	P	P	Z	P	P	P	Z
Exhaust Check															
Exhaust system	P, F, A, 4	P	P	P	Z	P	Z	P	P	P	Z	P	P	4	P
Overall	P, F	P	P	P	Z	P	Z	P	P	P	Z	P	P	4	P
Miscellaneous Check															
Miscellaneous items result	P, F, A, 4	P	P	P	Z	F	P	P	P	P	Z	P	P	P	Z
Miscellaneous comment result	P, F, A, 4	P	P	P	Z	4	P	P	P	P	Z	P	P	P	Z
Overall safety inspection result	P, F, Z, N	P	F	4	P	4	F	P	F	P	Z	F	P	4	P
Tampering Check															
Catalytic converter	P, F, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P	P	P	P	P	P
Gas Cap Test															
Accessible	Y, N	N/A	N/A	N/A	N/A	Y	Y	Y	N/A	Y	Y	Y	N	Y	Y
Can it be removed	Y, N	N/A	N/A	N/A	N/A	Y	Y	Y	N/A	Y	Y	Y	N/A	Y	Y
Does the cap fit the adapter?	Y, N - mark on VIR	N/A	N/A	N/A	N/A	Y	Y	N	N/A	Y	Y	Y	N/A	Y	Y
First test result	P, F - Ask if replace?	N/A	N/A	N/A	N/A	F	P	N/A	N/A	P	P	P	F	P	P
Replace cap	Y, N - Fail	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Retest	P, F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Overall result	P, F	N/A	N/A	N/A	N/A	F	P	N/A	N/A	P	P	P	F	P	P
Pressure Test															
Pressure test result	P,F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P	P
Test Preparation															
4WD/AWD non-disengagable	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N
Reason for non-dyn testable	1, 2, 3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Analyzer zero	P, F	P	P	P	P	P	P	P	P	P	P	P	P	P	P
HC hang-up check	P, F	P	P	P	P	P	P	P	P	P	P	P	P	P	P
RPM pickup device	Cont, non-cont, OBDII	CONT	CONT	NON	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT
Unstable RPM, bypass	Y, N	Y	N	N	N	N	N	P	N	N	N	N	N	Y	N

ASM/2500 RPM/IDLE TEST SCENARIOS															
Test Type	Options	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Brakes Check															
Service brake	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Parking brake	P, F, A, 4	P	P	P	P	P	P	P	P	P	F	P	P	P	P
Brake equalization	P, F, A, 4	F	P	P	P	P	P	P	P	P	P	P	P	P	P
Overall	P, F	F	P	P	P	P	P	P	P	P	F	P	P	P	P
Exhaust Check															
Exhaust system	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Overall	P, F	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Miscellaneous Check															
Miscellaneous items result	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Miscellaneous comment result	P, F, A, 4	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Overall safety inspection result	P, F, Z, N	F	P	F	P	P	P	P	P	P	F	F	P	P	F
Tampering Check															
Catalytic converter	P, F, N	P	P	P	P	N/A	P	P	F	P	P	P	P	P	P
Gas Cap Test															
Accessible	Y, N	Y	Y	Y	Y	N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y
Can it be removed	Y, N	N	Y	Y	Y	N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y
Does the cap fit the adapter?	Y, N - mark on VIR	N/A	Y	Y	Y	N/A	Y	Y	Y	Y	Y	Y	Y	Y	Y
First test result	P, F - Ask if replace?	F	F	F	P	N/A	F	P	P	F	F	P	F	F	P
Replace cap	Y, N - Fail	N/A	Y	Y	N/A	N/A	Y	N/A	N/A	Y	Y	N/A	Y	Y	N/A
Retest	P, F	N/A	P	P	N/A	N/A	P	N/A	N/A	P	P	N/A	P	P	N/A
Overall result	P, F	F	P	P	P	N/A	P	P	P	P	P	P	P	P	P
Pressure Test															
Pressure test result	P,F	P	P	N/A	P	P	P	P	P	P	P	P	F	P	P
Test Preparation															
4WD/AWD non-disengagable	Y, N	N/A	N/A	N/A	Y	N/A	N/A	N/A	N/A	N	N	N	N	N	N
Reason for non-dyn testable	1, 2, 3	N/A	N/A	N/A	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Analyzer zero	P, F	P	P	P	P	P	P	P	P	P	P	P	P	P	P
HC hang-up check	P, F	P	P	P	P	P	P	P	P	P	P	P	P	P	P
RPM pickup device	Cont, non-cont, OBDII	CONT	CONT	CONT	CONT	N/A	CONT	CONT	CONT	NON	CONT	CONT	CONT	OBDI:	CONT
Unstable RPM, bypass	Y, N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

ASM/2500 RPM/IDLE TEST SCENARIOS															
Test Type	Options	1	2	3	4	5	6	7	8	9	10	11	12	13	14
ASM Test															
Test weight source	VID (V), VRT (M), Def (D)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	M	M
Front wheel drive	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N
Tire drying	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	Y
More tire drying	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N
During test															
Speed violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N
Acceleration violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	N
Dilution violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N
RPM violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N
Dyno loading violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N
Emissions result	P, F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P
Restarted test															
Speed violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A
Acceleration violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	N/A
Dilution violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A
RPM violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A
Dyno loading violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A
Emissions result	P, F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Restarted test															
Speed violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A
Acceleration violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A
Dilution violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A
RPM violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A
Dyno loading violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A
Emissions result	P, F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	F	N/A

ASM/2500 RPM/IDLE TEST SCENARIOS															
Test Type	Options	15	16	17	18	19	20	21	22	23	24	25	26	27	28
ASM Test															
Test weight source	VID (V), VRT (M), Def (D)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	V	V	V	M	V	V
Front wheel drive	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	Y
Tire drying	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	Y	N	N
More tire drying	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	Y	N	N
During test															
Speed violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	N	N	N	N	N
Acceleration violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N
Dilution violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N
RPM violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	Y
Dyno loading violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N	N	N	N	N
Emissions result	P, F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P	F	P	P	N/A
Restarted test															
Speed violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N
Acceleration violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N
Dilution violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	N/A	N/A	N/A	N/A	N
RPM violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N
Dyno loading violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N
Emissions result	P, F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P
Restarted test															
Speed violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A
Acceleration violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	N/A	N/A	N/A	N/A	N/A
Dilution violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A
RPM violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A
Dyno loading violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A
Emissions result	P, F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	F	N/A	N/A	N/A	N/A	N/A

ASM/2500 RPM/IDLE TEST SCENARIOS															
Test Type	Options	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2500 RPM Test															
Dunng test															
Dilution violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RPM violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low flow violation	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Emissions result	P, F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Restarted test															
Dilution violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RPM violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low flow violation	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Emissions result	P, F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Restarted test															
Dilution violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RPM violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low flow violation	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Emissions result	P, F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Second Chance Test															
Dilution violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RPM violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low flow violation	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Emissions result	P, F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Restarted test															
Dilution violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RPM violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low flow violation	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Emissions result	P, F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

ASM/2500 RPM/IDLE TEST SCENARIOS															
Test Type	Options	15	16	17	18	19	20	21	22	23	24	25	26	27	28
2500 RPM Test															
During test															
Dilution violations	Y, N	N/A	Y	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RPM violations	Y, N	N/A	N	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low flow violation	Y, N	N/A	N	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Emissions result	P, F	N/A	N/A	N/A	F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Restarted test															
Dilution violations	Y, N	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RPM violations	Y, N	N/A	Y	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low flow violation	Y, N	N/A	Y	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Emissions result	P, F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Restarted test															
Dilution violations	Y, N	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RPM violations	Y, N	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low flow violation	Y, N	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Emissions result	P, F	N/A	P	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Second Chance Test															
Dilution violations	Y, N	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RPM violations	Y, N	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low flow violation	Y, N	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Emissions result	P, F	N/A	N/A	N/A	F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Restarted test															
Dilution violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RPM violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low flow violation	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Emissions result	P, F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

ASM/2500 RPM/IDLE TEST SCENARIOS															
Test Type	Options	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Idle Test															
During test															
Dilution violations	Y, N	N	N	N	Y	N	N	N	N/A	N	N	N	N/A	N/A	N/A
RPM violations	Y, N	N	N	N	N	N	Y	N	N/A	N	N	N	N/A	N/A	N/A
Low flow violation	Y, N	N	N	N	N	Y	N	N	N/A	N	N	N	N/A	N/A	N/A
Emissions result	P, F	F	P	F	N/A	N/A	N/A	P	N/A	F	P	P	N/A	N/A	N/A
Restarted test															
Dilution violations	Y, N	N/A	N/A	N/A	N	N	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RPM violations	Y, N	N/A	N/A	N/A	N	N	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low flow violation	Y, N	N/A	N/A	N/A	N	Y	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Emissions result	P, F	N/A	N/A	N/A	P	N/A	P	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Restarted test															
Dilution violations	Y, N	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RPM violations	Y, N	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low flow violation	Y, N	N/A	N/A	N/A	N/A	Y	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Emissions result	P, F	N/A	N/A	N/A	N/A	F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Second Chance Test															
Dilution violations	Y, N	N	N/A	N	N/A	Y	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A
RPM violations	Y, N	N	N/A	N	N/A	N	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A
Low flow violation	Y, N	N	N/A	N	N/A	N	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A
Emissions result	P, F	F	N/A	P	N/A	N/A	N/A	N/A	N/A	P	N/A	N/A	N/A	N/A	N/A
Restarted test															
Dilution violations	Y, N	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RPM violations	Y, N	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low flow violation	Y, N	N/A	N/A	N/A	N/A	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Emissions result	P, F	N/A	N/A	N/A	N/A	P	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Visible smoke test	P, F, Z	F	P	P	P	P	P	P	P	P	P	F	P	P	P
OVERALL RESULTS															
Overall safety	P, F, Z, 4	P	F	4	P	4	F	P	F	P	Z	F	P	4	P
Tampering	P, F, Z, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P	P	P	P	P	P
Pressure		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	P	P
Gas cap	P, F, Z, N	N/A	N/A	N/A	N/A	F	P	N/A	N/A	P	P	P	F	P	P
Emissions	P, F, W, Z, N	F	P	P	P	P	P	P	N/A	P	P	P	N/A	F	P
Smoke	P, F, Z	F	P	P	P	P	P	P	P	P	P	F	P	P	P
Overall Emissions		F	P	P	P	P	P	P	P	P	P	F	F	F	P
Overall	P, F	F	F	F	P	F	F	P	F	F	P	F	F	F	P
Test fee															
Sticker date		REJ	REJ	REJ	#######	REJ	REJ	#######	REJ	REJ	#NAME?	REJ	REJ	REJ	#NAME?
TIN															

ASM/2500 RPM/IDLE TEST SCENARIOS															
Test Type	Options	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Idle Test															
During test															
Dilution violations	Y, N	N/A	N/A	N	N/A	N/A	N	N	N	N/A	N/A	N/A	N/A	N/A	N/A
RPM violations	Y, N	N/A	N/A	N	N/A	N/A	N	N	N	N/A	N/A	N/A	N/A	N/A	N/A
Low flow violation	Y, N	N/A	N/A	N	N/A	N/A	N	N	N	N/A	N/A	N/A	N/A	N/A	N/A
Emissions result	P, F	N/A	N/A	P	N/A	N/A	F	F	P	N/A	N/A	N/A	N/A	N/A	N/A
Restarted test															
Dilution violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RPM violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low flow violation	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Emissions result	P, F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Restarted test															
Dilution violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RPM violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low flow violation	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Emissions result	P, F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Second Chance Test															
Dilution violations	Y, N	N/A	N/A	N/A	N/A	N/A	N	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RPM violations	Y, N	N/A	N/A	N/A	N/A	N/A	N	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low flow violation	Y, N	N/A	N/A	N/A	N/A	N/A	N	N	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Emissions result	P, F	N/A	N/A	N/A	N/A	N/A	F	P	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Restarted test															
Dilution violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RPM violations	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Low flow violation	Y, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Emissions result	P, F	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Visible smoke test	P, F, Z	P	P	P	P	P	P	P	P	P	P	P	P	P	P
OVERALL RESULTS															
Overall safety	P, F, Z, 4	F	P	F	P	P	P	P	P	P	A	F	P	P	F
Tampering	P, F, Z, N	P	P	P	P	N/A	P	P	F	P	P	P	P	P	P
Pressure		P	P	N/A	P	P	P	P	P	P	P	P	F	P	P
Gas cap	P, F, Z, N	F	P	P	P	N/A	P	P	P	P	P	P	P	P	P
Emissions	P, F, W, Z, N	P	P	P	F	N/A	P	P	P	F	P	F	P	P	P
Smoke	P, F, Z	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Overall Emissions		F	P	P	F	P	P	P	F	F	P	F	F	P	P
Overall	P, F	F	P	F	F	P	P	P	F	F	F	F	F	P	F
Test fee															
Sticker date		REJ	#NAME?	REJ	REJ	#NAME?	#NAME?	#NAME?	REJ	REJ	REJ	REJ	REJ	#NAME?	REJ
TIN															

Additional Checks to be Performed on Test Systems		
Item	Condition	Pass
1	Cabinet open lockout	
2	Check for UL label on cabinet	
3	Does training VIR have VOID on it	
4	Record search, copy to floppy	
5	Can not hold down a key and fill in fields	
6	Calibration procedures for analyzer	
7	Calibration procedures for gas cap tester	
8	Calibration procedures for dynamometer	
9	Leak check fail	
10	Test technician security	
11	Print screen disabled during inspection	
12	No key buffering	
13	State lockout not cleared by VID download	
14	Single letter chooses a menu item	
15	If lockout, display message and return to main menu	
16	Fan prompt or turns on automatically if above 72 degrees	
17	Find and print duplicate VIR with "duplicate" and date printed on it	
18	Displays "testing" while sampling	
19	Check transaction ID number (TIN) algorithm	
20	Perform gas audit	
21	Install new data disk	
22	Set State lockout	
23	Clear State lockout	
24	Update station information	
25	Bar code reader failure limits	
26	Inspector time limit for manual entry of ID	
27	Invalid station license	
28	Communications ANI rejection	
29	Data corruption check	
30	Prints messages when downloaded	
31	Prints recall when downloaded	
32	Power down before, during, and after an emissions test	
33	Restore files from diskette	
34	Disconnect phone line between first and second VID call	
35	Attempt to back out of test sequence with edit keys	
36	"esc" key causes abort after inspector enters ID	
37	Attempt entry to DOS through optional software	

ASM Test Conditions		
	Test Item	**Conditions**
1	RPM Setup	If 1996+ prompt to use OBDII port request type used be entered
2	Front Wheel Drive?	Front wheel drive prompt "Front-wheel drive vehicle Laterally stabilize, restrain and chock"
		Rear wheel drive prompt "Rear-wheel drive vehicle Restrain and chock"
3	Vehicle Alignment and Restraints	Will not allow test if restraints not in place
4	Cooling Fan Prompt if > 72 deg F	Can be optionally turned on automatically
5	Sample Probe Hookup	
6	Gear Selection	1 automatic transmissions engine <= 3 0L 3000 rpm, suggest use of "drive"
		2 automatic transmissions engine > 3 0L, 2500 rpm, suggest use of "drive"
		1 manual transmission, engine <= 3 0L, 1500 - 3000 rpm, suggest use of "2nd gear"
		2 manual transmission, engine > 3 0L, 1250 - 2500 rpm, suggest use of "2nd gear"
7	Tire Drying (y/n)	1) drying at < 30mph increment clock 1X/sec
	more drying? (y/n)	2) drying at > 30mph or 3000 rpm, increment clock 2X/sec
		3) maximum delay = 30 seconds
8	Pretest Conditions (delay start of test)	1) zero not performed ambient air check not complete, HC hang-up failed/incomplete
		2) low flow
		3) idle not between 400-1250 RPM
		4) dyno rolls turning (speed > 1mph)
		5) delay start twice time of high idle or rolls turning, maximum delay = 30 seconds
		6) count down delay unless rollers < 1 mph or RPM < 1250 increase at 1 second per second turning
		7) again count down delay
9	ASM Test Mode	1) speed, RPM, dyno loading and dilution not within spec within 25 seconds, restart
		2) roll speed, RPM dyno loading and dilution within spec for 5 seconds, start test timer (if > 10 and < 25 subtract difference from mode timer)
		3) display test speed with limits test time, engine RPM
		4) at 25 seconds start pass/fail determination
		5) during emissions averaging portion of the test, monitor vehicle acceleration if > 0 6 mph/sec (or SYSTEM DAT spec)
		a) display acceleration error prompt
		b) increment acceleration violation counter, go to restart if count =5 or accumulated acceleration time > 5 seconds
		c) do not use time aligned transient throttle data for emission averaging
		d) delay sampling for 5 seconds after time aligned acceleration violation ends
		e) if less than 10 seconds remain in test after sampling is restarted use last 10 sec average without acceleration for pass/fail determination
		6) during emissions averaging portion of the test, restart the test if
		a) dilution for more than 2 seconds
		b) dyno loading out of tolerance 2 consecutive seconds or 5 seconds accumulated
		c) vehicle speed out of tolerance (+/-1mph) for 5 seconds at any one time
		d) engine RPM out of tolerance for more than 2 seconds
		e) acceleration violation 5 times or 5 seconds
		7) if average simultaneous readings are all less than or equal to spec and speed has not decreased by 0 5 mph, vehicle passes
		8) if test time expires and pass is not obtained, vehicle fails, log average of last 10 seconds
		9) at end of mode timer, apply augmented braking, warn driver on screen any time augmented braking is applied
10	ASM Restart Procedures	1) bring rollers to full stop (augmented braking is to be applied).
		2) reset all violations counters to zero
		3) increment number of restarts counter, if >2, end the test
		4) delay at RPM < 1250 roll speed < 1mph,
		5) delay time = 2X previous running time maximum delay = 60 seconds
		6) return to ASM test mode

Idle and 2500 RPM Test Conditions		
	Test Item	**Conditions**
1	Special Test Sequence?	If so, record in EIS DAT field 41, provide special prompts
2	RPM Setup Ignition Type	If 1996+ prompt to use OBDII port, request type used be entered
3	Sample Probe Hookup	
4	Pretest Conditions to Start Testing Period	1) zero not performed, ambient air check not complete, HC hang-up failed/incomplete
		2) low flow
		3) CO + CO2 must be greater than 6%
		4) RPM meeting limits for test (400-1250 for idle test, 2250-2750 for 2500 RPM test)
5	Emissions Test	1) vehicle in neutral or park
		2) engine RPM within limits
		3) display test RPM with limits, test time
		4) at 10 seconds start pass/fail determination, 5 second average
		5) maximum elapsed time is 30 seconds for mode
6	Restart Conditions	1) RPM outside limits for test (400-1250 for idle test, 2250-2750 for 2500 RPM test) for 2 or 10 seconds
		2) low flow
		3) CO + CO2 less than 6%
7	Second Chance Test	1) 2500 RPM test - idle for 30 seconds, retest
		1) idle test - rev up to 2200-2650 rpm for 30 seconds, if less tan 2200 rpm for more than 2 seconds, warn, after revving, retest at idle
		DO NOT rev special test types 3 or 5 (with ZF transmissions)

Acceptance Testing Problem Tracking Log

Item #	Date Found	Level 1	Level 2	Level 3	Problem Description	Notes	Fixed OK	Date Fixed
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								

Page Number _____

Acceptance Testing Problem Tracking Log

Item #	Date Found	Level 1	Level 2	Level 3	Problem Description	Notes	Fixed OK	Date Fixed

Page Number _____

Beta Test Station Problem Tracking Sheet

Facility Name:	Facility Phone Number:
Facility Address	Software Version #:
Facility Number	Page #

Please make descriptions as detailed as possible. Use more than one set of blocks if necessary.

Date / Time	Problem / Issue / Suggestion	Exact Description of Where Problem Occurred in Software	VIN (attach VIR if possible)

APPENDIX B. TRAINING COURSE PRESENTATION

US EPA I/M TEST SYSTEM AUDIT TRAINING

Michael St. Denis
Sierra Research, Inc.

Outline

- Overview of acceptance testing
- Overview of calibrations
- Field auditing issues
- Auditing equipment and costs
- Audit vehicles
- Record keeping
- Retesting of failed test systems
- Component training
- Hands-on training

Outline – continued
Components to be audited

- Visual inspection
- Weather station
- Gas benches (NDIR and fuel cell)
- Tachometer
- Dynamometer
- Gas cap tester
- Pressure tester
- OBDII scan tool
- VMAS unit

Outline – Continued
Component Audit Training

- For each test system audit, the following will be covered:
  - Component theory of operation
  - Required audit equipment
  - Audit procedure
  - Calculations and record keeping
  - Audit tolerances
  - Common audit failures and equipment issues

Total QA/QC Program

- The auditing is only one component of an integrated quality assurance/quality control program aimed at ensuring that the equipment is properly designed and maintained. This QA/QC program can be divided into three primary elements:
  - Initial acceptance and beta testing of the equipment
  - Ongoing, automatic calibrations and checks programmed into the equipment
  - Equipment audits that are performed on a routine basis combined with analysis of calibration and audit data to find trends in performance

Auditing Issues

- New hardware or hardware uses have been added
  - VMAS
  - OBDII scanners
  - Transient tests with ASM dynamometers
- Previous EPA Work Assignment (2-05) developed audit procedures for all components
- Report provides information about previous failures, there needs to be more sharing of info between states
- Report provides details on required equipment and costs
- There is disagreement over some of the audit tolerances
- Most audit programs are not meeting EPA requirements, some not auditing at all, cost is a significant issue
- Audit menus are not available on many systems

Acceptance Testing

- Quality Control CFR40 §51 359
- Acceptance testing is important to ensure internal decisions and calculations that cannot be checked in auditing are functioning properly, prevents "incurable" audit failures
- Hardware generally not tested, BAR97 certification accepted
- Some manufacturers have changed hardware on BAR97 certified systems
- Beta testing must be conducted, tracked, and the bugs fixed
- Appropriate time must be allotted for ATP and beta testing
- Special equipment for acceptance testing
  - BAR97 high and low gases
  - Dynamometer simulators
  - RPM and OBDII simulators
  - VID connection and VID data management tools
  - Possible connection to state motor vehicles department

Acceptance Testing Components

- Main menus
- Inspection menus
- Inspection scenarios (test logic checks)
- Test conditions (timers, dilution, restart, RPM/OBDII connection, etc)
- Additional checks (VIR's, lockouts, security, tampering, comm, etc)
- Calculations (emissions, correction factors, sticker dates, etc)
- Calibrations (frequency, lockouts, calculations, etc)
- Data files (proper storage, format, logic)
- Audit menus
- Lookup table data matching
- Gas sample time alignment
- Dynamometer parasitics, temperature correction and loading
- Humidity correction factor

Calibrations

- Differences between high and low volume (4,000 vehicles per year) requirements, ignored by most states
- Gas bench
  - Daily leak check
  - 3-day two point gas calibration
- Dynamometer
  - 3-day coast down, if fail
    - Parasitic determination
    - Load cell calibration
  - Weekly speed checks not conducted
- Gas cap tester - Daily
- Pressure tester - Daily
- VMAS – Weekly hose-off flow check
- Issues with calibration discussed in audit issues section

Auditing Objectives

- Quality Assurance CFR40 §51.363:

  "An ongoing quality assurance program shall be implemented to discover, correct and prevent fraud, waste, and abuse and to determine whether procedures are being followed, are adequate, whether equipment is measuring accurately, and whether other problems might exist which would impede program performance"

Auditing Requirements

- Requirements in §51.363(c) for equipment audits
  - Twice a year for each lane or test bay
  - (1) + (7) gas audit and check of station gas bottles
  - (2) tampering, wear and filters
  - (3) + (4) CVS and CFV = VMAS
  - (5) FID – not used in ASM equipment
  - (6) leak check
  - (8) dynamometer tests
  - (9) measure background concentrations
  - (10) + (11) pressure and purge = gas cap and pressure tester

Field Auditing Issues

- Audit menus
- Audit equipment
- Interrupting inspections
- Lockouts
- Retests
- Record keeping

Audit Menus

- Audit menus not clearly defined or not required in most specifications
- Access to all menus should be through state access menu
- State access should have ability to lockout the analyzer
- Should display
  - Weather station data (temperature, humidity, barometric pressure)
  - HC (propane), CO, CO_2, NO, and O_2 concentrations (should have the ability to zero the analyzer
  - RPM reading (inductive and OBDII)
  - Dynamometer speed, load cell reading, coast down, and parasitic measurement data
  - Gas cap tester test function with pass/fail result
  - Pressure tester test function with pass/fail result
  - OBDII test data (MIL commanded on, readiness status, DTC's)
  - VMAS temperature, pressure, flow rate, factory VMAS flow rate and oxygen concentration (should have ability to calibrate oxygen sensor)

Auditing Equipment and Costs

- Depends on which components are audited
- Need several of some items
- May be alternative methods that are less expensive
- Need to be careful to check accuracy of instruments
- Need to ensure instruments are NIST traceable
- Need to be able to recalibrate all equipment on a regular basis to ensure it is accurate

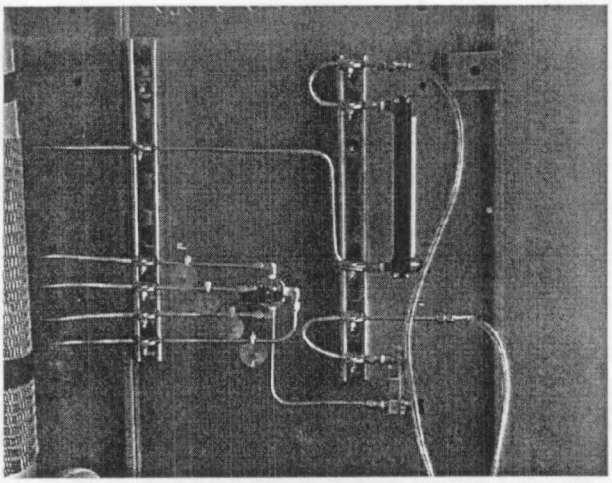
Audit Equipment Costs		
#	Item	Cost/Item
1	Audit van	--
2	Gas cylinder racks with regulators, plumbing and output panel	$10 000
3	High audit gas, AQ or AS size cylinder	$250
4	Mid-1 audit gas, AQ or AS size cylinder	$250
5	Mid-2 audit gas, AQ or AS size cylinder	$250
6	Low audit gas, AQ or AS size cylinder	$250
7	1% oxygen in nitrogen audit gas, AQ or AS size cylinder	$200
8	10% oxygen in nitrogen audit gas, AQ or AS size cylinder	$200
9	20% oxygen in nitrogen audit gas, AQ or AS size cylinder	$200
10	Zero air, AQ or AS size cylinder	$75
11	Single stage stainless steel gas regulators, CGA 660	$425
12	Single stage brass air regulators, CGA 590	$175
13	Three way switching valve and flow meter	$1 300
14	50 foot roll 1/4" ID x 3/8" OD Tygon tubing	$55
15	Hose tees, 1/4" x 1/4" x 1/4"	$2
16	Barbed regulator connectors	$2
17	50 feet roll of bubble tubing	$35
18	Balloons and rubber bands	$2
19	Portable temperature and humidity weather station (psychrometer)	$140
20	Barometer	$1 800
21	Reference "pass" fuel cap	$100
22	Reference "fail" fuel cap	$100
23	Vehicle pressure test audit tool	$850
24	RPM simulator	$250
25	OBDII simulator	$3 500
26	Laptop computer	$2 000
27	SAO 200 to 500 SCFM	$5 000
28	4" blast gate valve	$15
29	Dynamometer tester	$20 000

Audit Vehicles

- Cargo vans are ideal
- Some suggest use of pickups with camper shell to separate gases from driver
- Should be capable of carrying up to 8 gas cylinders in gas racks
- Want to avoid having to reconnect audit gases at each location, can use split caps
- Should have rear and side gas distribution panels
- Should have work area
- Should have power inverter
- Should have vented gas storage area with gas detectors
- Partition between driver and equipment

Interior of Audit Van

Audit Van Gas Distribution



Lockouts and Retests

- If there is a failure, auditor should be able to lock out the analyzer
- BAR has two sets of audit failure standards:
  - Service soon
  - Lockout till serviced
- Some states have field service reps repeat audit after service and remove lockout if passed
- Some states require state to retest before removing lockout

Record Keeping / Triggers

- Data can be entered onto paper and calculation done by hand, must be later entered into database
- Data can be entered directly into software that performs calculations, makes pass/fail decisions, must print report signed by auditor
- Copy of report left with station so that field service representatives will know what to fix if there is a failure
- Data transmitted to database for later analysis
- Can use calibration data in triggers to target audits, and use audit data to confirm trigger accuracy and improve triggers

Component Training

1. Visual inspection
2. Weather station
3. Gas benches (NDIR and electrochemical cell)
4. Tachometer
5. Dynamometer
6. Gas cap tester
7. Pressure tester
8. OBDII scan tool
9. VMAS unit

Component Audit Training

- For each test system audit, the following will be covered:
  - Component theory of operation
  - Required audit equipment
  - Audit procedure
  - Calculations and record keeping
  - Audit tolerances
  - Common audit failures and equipment issues

1. Visual Inspection

- To determine if the system has been tampered
- Determine if proper preventative maintenance is being conducted
- Ensure proper calibration equipment is being used and proper values for calibration gases are entered
- Look for signs of overt cheating

Visual Inspection Items to be Checked

- All pieces of equipment are properly housed
- All pieces of equipment are clean and orderly
- There are no signs of tampering
- HC filter is clean
- Correct calibration gas values are entered
- The dynamometer (if used) is connected to the test system and power
- Vehicle restraints are present (if dynamometer is used)
- Gas cap tester (if used) is connected to the test system
- Gas cap standard is not left on tester by shop
- The VMAS unit is connected to the test system and power (if used)
- Shop does not have an RPM simulator on tachometer pickup
- ZAG filters changed at appropriate times

Common Visual Inspection Failures

- Not changing the HC filter
- Not emptying the water filter bowl
- Gas cap tester calibration device connected to tester
- Gas cylinder values not updated
- Calibration gas cylinders not tampered (such as for refilling with shop air)
- Calibration gas cylinder labels not removed
- Shop air used to fill zero air cylinder or plumbed into analyzer (sometimes around zero air generator)
- RPM simulator on tachometer pickup
- Gas cap tester standard not left on tester
- Tape covering hold in raw sample hose or signs of kinking the hose to pass the leak check

2. Weather Station Audit

- The weather station reports
  - Humidity
  - Temperature
  - Barometric pressure
- Humidity and temperature are used in humidity correction factor for NO_x measurements
- Temperature used for lockout if outside allowed operation temperature window (35 to 110°F)
- Barometric pressure reported by analyzer used to adjust emissions readings
- Barometric pressure and temperature in VMAS are used for VMAS flow corrections to STP

Weather Station Audit Equipment

- For temperature and humidity use a psychrometer
  - Thermometer is to be accurate to less than 1°F
  - Humidity is to be accurate to less than 1% RH
  - Works by blowing air over a wet bulb and comparing the difference between a dry and the wet thermometers
- For pressure, use a barometer
  - Accuracy is better than 0.25% of point

Weather Station Audit Tolerances

- For temperature
  - Audit measurement is to be accurate to less than 1°F
  - Analyzer temperature accuracy is to be 3°F
  - Audit tolerance is 4°F
- For humidity
  - Audit measurement is to be accurate to less than 1% RH
  - Analyzer humidity measurement accuracy is to be 3% RH
  - Audit tolerance is 4% RH
- For pressure
  - Audit measurement is to be accurate to less than 0 25% of point
  - Analyzer pressure measurement accuracy is to be 3% of point
  - Audit tolerance is 3% of point

Weather Station Audit Issues

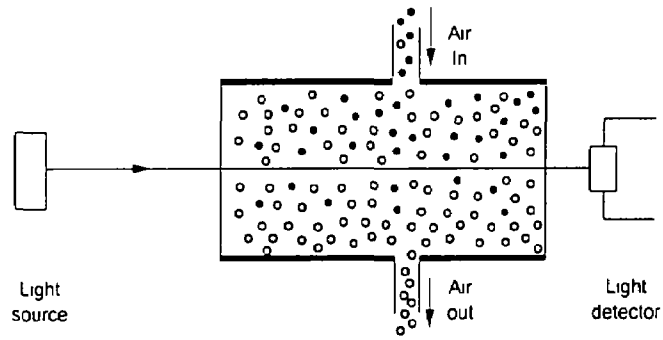
- Ambient temperature sensors improperly located inside the equipment cabinet, biasing readings
- Weather station data not displayed by some analyzers
- Weather stations sensitive to analyzer location
- A manufacturer in one program hard coded the temperature and humidity readings in all its test systems
- The weather stations are supplied with coefficients that are the calibration of the weather station (such as 1 volt equals 30 degrees), manufacturer field service representatives change weather stations without changing calibration coefficients

3. Analyzer Gas Audit

- All gas audits should start with a leak check
  - Leak check extra important for VMAS systems
- Gas audits:
  - Four gas
  - Five gas
  - Five gas with oxygen check for VMAS use

How NDIR Analyzers Function

Transmission Spectroscopy
with continuous-flow sampling



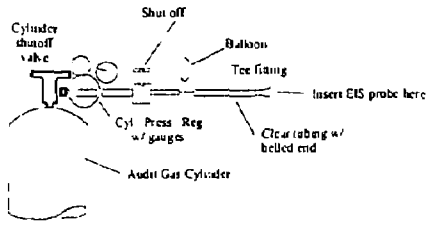
Analyzer Audit Equipment

- Tygon tubing
- Bubble tubing (used to adapt the tubing to the analyzer probe tip)
- Tygon hose tee
- Balloons
- Five or six audit gases, 1% accuracy with 2% blend tolerance
- Single stage gas regulators (brass and stainless steel) with shut off, barbed output

Analyzer Audit Gases

	O_2 %	HC PPM	CO %	CO_2 %	NO PPM	N_2
BAR zero	20 9	1	1	200	1	Bal
EPA zero	20 7	0 1	0 5	1	0 1	Bal
Low	0	200	0 5	6 0	300	Bal
Low Mid	0	960	2 4	3 6	900	Bal
High Mid	0	1920	4 8	7 2	1800	Bal
High	0	3200	8 0	12 0	3000	Bal
VMAS Oxygen Check	1 0	1	[illegible]	200	1	Bal

Analyzer Audit Procedure - Setup



- Record gas concentrations on audit form
- Stainless steel regulators on gases containing NO
- Balloon for approximating pressure balanced flow
- Balloon near probe end
- Audit from low to high concentration
- Display bench readings, ensure HC is displayed in ppm propane

Analyzer Audit Procedure

- Perform a leak check
  - First without a cap to ensure a fail
  - Re-check with the cap in place, analyzer should pass
  - If the analyzer does not pass, allow shop to repair the analyzer (replace probe or hose) before continuing the gas audit
- Zero analyzer – this may or may not be done automatically when entering a gas concentration display mode
- Connect the belled fitting over the sample probe
- Flow zero gas, balloon should barely inflate
- Record readings after one minute
- Turn off gas and remove sample line, allow analyzer to sample ambient air until NO reading is below 20 ppm
- Repeat procedure with 1% oxygen if using a VMAS, then other gases

Spreadsheet for Calculating ASM Audit Tolerances

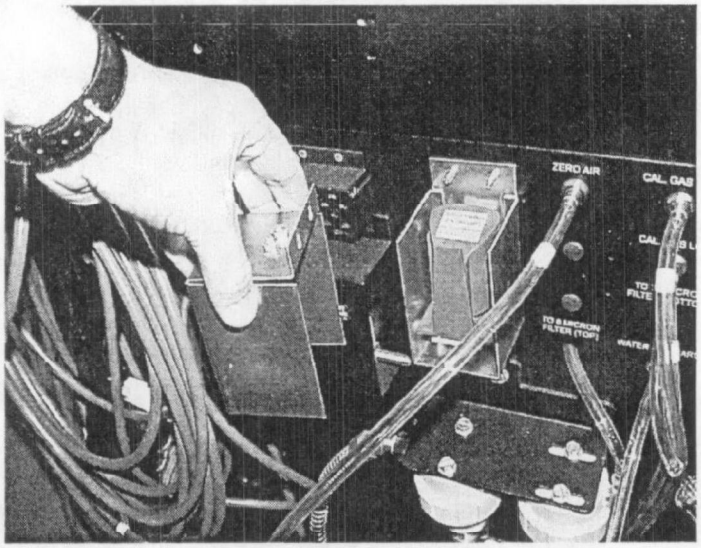
Range	Gas	Gas Concentration		Audit Tolerance			Applied Tolerance (greater of % or point)	Audit Limits	
		Recom mended	Actual Cylinder	%	% (as point)	Point		Low	High
High	HC (ppm)	3200	3191	4 0%	128	40	128	3063	3319
	CO (%)	8 00	8 11	4 0%	0 32	0 10	0 32	7 79	8 43
	CO2 (%)	12 00	11 90	4 0%	0 48	0 42	0 48	11 42	12 38
	NO (ppm)	3000	2987	5 0%	149	55	149	2838	3136
Mid High	HC (ppm)	1920	1918	4 0%	77	27	77	1841	1995
	CO (%)	4 80	4 63	4 0%	0 19	0 07	0 19	4 64	5 02
	CO2 (%)	7 20	7 15	4 0%	0 29	0 37	0 37	6 78	7 52
	NO (ppm)	1800	1801	5 0%	90	43	90	1711	1891
Mid Low	HC (ppm)	960	960	4 0%	38	18	38	922	998
	CO (%)	2 40	2 39	4 0%	0 10	0 04	0 10	2 29	2 49
	CO2 (%)	3 60	3 57	4 0%	0 14	0 34	0 34	3 23	3 91
	NO (ppm)	900	902	5 0%	45	34	45	857	947
Low	HC (ppm)	200	203	4 0%	8	10	10	193	213
	CO (%)	0 50	0 49	4 0%	0 02	0 02	0 02	0 47	0 51
	CO2 (%)	6 00	6 01	4 0%	0 24	0 36	0 36	5 65	6 37
	NO (ppm)	300	299	5 0%	15	28	28	271	327
Zero	HC (ppm)	0	0	4 0%	0	9	9	-9	9
	CO (%)	0 00	0 00	4 0%	0 00	0 02	0 02	-0 02	0 02
	CO2 (%)	0 00	0 00	4 0%	0 00	0 30	0 30	-0 30	0 30
	NO (ppm)	0	0	5 0%	0	26	26	26	26
	O2	20 9	20 9	6 0%	1 3	0 5	1 3	19 6	22 2
VMAS	O2	1 00	1 05	6 0%	0 06	0 31	0 31	0 74	1 36

In the 'Actual Cylinder' column enter the gas concentrations from the audit cylinders
The audit low and high tolerances are calculated in the columns on the right

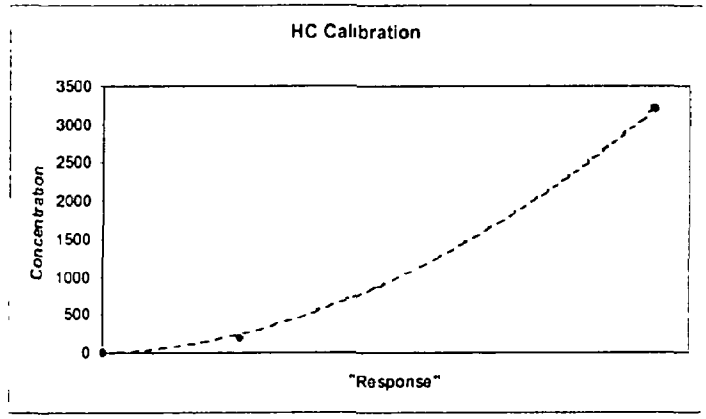
Analyzer Audit Issues

- High accuracy failure rate, especially for HC
- Old or incorrect humidity correction factor
- Time alignment, even transient programs in incorrect
- For VMAS systems, original NY data stated sample conditioning (e.g., a chiller) appears necessary
- Gas benches on new test systems have been found to fail
- High volume stations calibration every four hours and monthly multi-point calibrations
- NOx outlet venting changed or mounted exterior to cabinet
- Some manufacturers have resorted to doing a "Cal High, Cal Low" procedure every time a calibration is required
- NOx cells response time and life time, "Rev 4" cells now sold, new analyzers coming currently being certified

Accessible NOx Cell on ASM Analyzer



Two Point Calibration
"Cal High, Check Low"



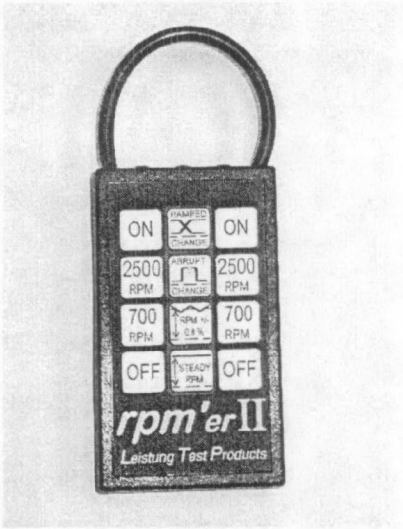
NO Cell / Analyzer Issues

- Many NO cells were failing audits with a response time limit of 6 5 seconds BAR increased the allowable response time limit to a maximum of 9 5 seconds This is a significant problems for programs using the cells to perform transient tests
- NO cell life time – City Technologies said the cells should last from 3 months to 9 months Many programs extending their use for up to two years Cell cost is approximately $250
- Rev "A" cells not longer available, only Rev "4" cells available
- BAR wanted City Technologies to certify, but in the absence of that, asked test system manufacturers to recertify with Rev 4 cell
- New analyzers coming currently in development of being certified
  - Sensors NDUV
  - Horiba NDIR
  - Andros NDIR
- Costs range from $750 to $1,500

4. RPM Measurement Audit

- Check inductive tachometer pickup
- Check OBDII RPM reporting ability
- "Wand"-type pickups cannot be audited

RPM Inductive Audit Equipment



RPM OBDII Audit Equipment

RPM Measurement Audit Procedure

- Set the analyzer to display RPM
- If requested, set it to use the inductive pickup
- Connect the RPM simulator to the inductive pickup
- Record readings at 700 and 2500 rpm
- Set the analyzer to use the OBDII RPM system
- Connect the OBDII simulator to 700/2500 RPM setting
- The simulator will remain at 700 for five seconds and then switch to 2500 RPM
- Record readings at both 700 and 2500 RPM
- Allowed tolerance is 3%

RPM Measurement Audit Issues

- Inductive tool is expensive ($250)
- OBDII RPM simulator is expensive ($3,500), may only be used if OBDII testing is also being conducted
- If tachometers fail they do not impact test results because they usually are not inaccurate, they cease to function, which would prevent tests or allow RPM to be bypassed
- If an OBDII RPM simulator is not available, use a vehicle with a tachometer and operate the vehicle at idle and 2500, recording readings, allowed tolerance is 10%
- "Wand"-type RPM pickups cannot easily be audited

5. Dynamometer Audit

- Type of audit depends on dynamometer use:
  - Steady-state use audit (ASM test)
    - Only check loaded coast down
    - Loading accuracy checked at ATP
  - Transient use audit (MA31, NYTEST)
    - Check loaded coast down
    - Check inertia simulation accuracy during a test

Transient Vehicle Loading

- The vehicle is supposed to be tested on the dynamometer at a load simulating driving on-road
- This load is Track Road Load Horsepower (TRLHP) plus inertia force
- TRLHP is the sum of frictional forces (aerodynamic drag, bearing friction, etc) and is a function of speed
- Inertia force from accelerating a mass and therefore is a function of acceleration
- TRLHP and inertia weights are provided in the EPA/Sierra Lookup Table (ESLT)

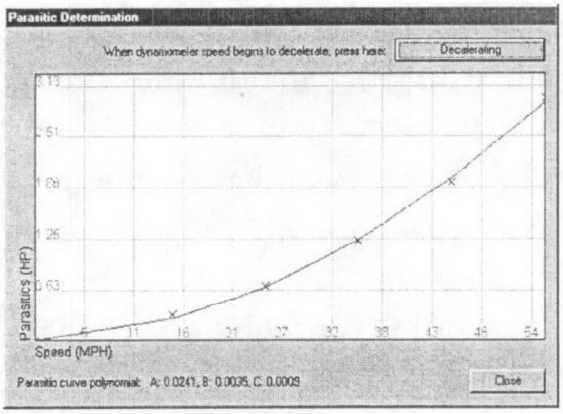
Force Applied by Dynamometer

- The force applied by the dynamometer should be equal to TRLHP + Inertia force
- The dynamometer applies force to the vehicle in three ways:
  - The power absorption unit (PAU)
  - The resistance in the dynamometer called "Parasitic Losses" (PL)
  - The friction at the tire/roll interface (GTRL)

How Dynamometer Forces are Determined

- Power absorber – The dynamometer has a strain gauge ("load cell") that measures the force applied
- Parasitic losses – this is determined by coasting the dynamometer down and measuring the rate at which the dynamometer slows
- Friction at the tire/roll interface – EPA provides equations to calculate "Generic" tire/roll losses (GTRL) for vehicles based on the drive axle weight

Determination of Parasitic Losses



Dynamometer Coast Down Check

- A random horsepower setting is chosen
- A coast down with that power applied is conducted
- The time to coast down through a speed window is measured and compared to a theoretical time
- Dynamometer should compensate for parasitic drag
- For ASM dynamometers, 7% error is allowed
- For IM240 dynamometers, 1 second from 55 to 45 mph (15 to 20 seconds), 6 seconds from 22 to 18 mph (22 to 33 seconds)

Dynamometer Inertia Simulation Tester Principle of Operation

- A dynamometer should simulate the load a vehicle would see under identical operating conditions (speed and acceleration) on-road
- The theoretical load that a vehicle should receive is compared to the load the vehicle actually received on the dynamometer.
- Both overall (over the whole test) and instantaneous power applied are evaluated

How is Error Determined?

Inertia + TRLHP = PAU + PL + GTRL

Or

PAU = Inertia + TRLHP - PL - GTRL

- PAU power measured at the load cell, Inertia, TRLHP, PL, and GTRL determined from calibration or calculation based on vehicle characteristics and measured speed and acceleration

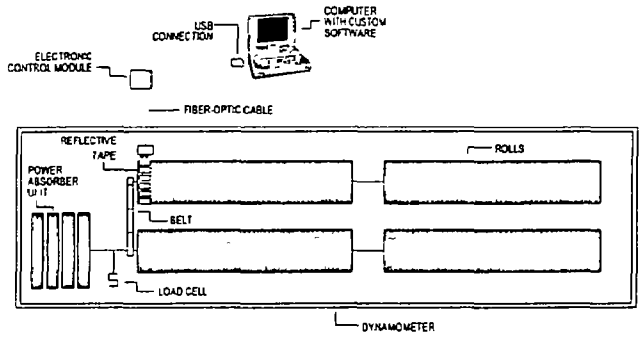
Two Types of Error Calculated

- Overall HP Simulation Error (OHPSE)
  - Second-by-second errors are calculated for every second and averaged over the entire trace (except during decelerations on eddy current dynamometers)
- Maximum Instantaneous HP Simulation Error (IHPSE)
  - Error calculated as an average over five second intervals, highest single average is recorded as maximum instantaneous error

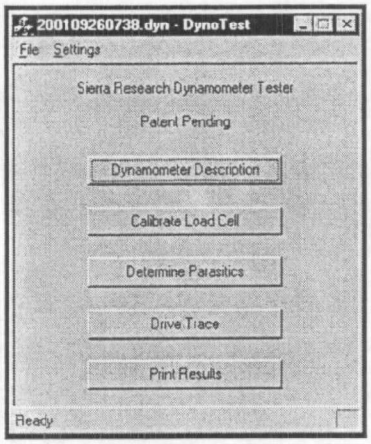
Dynamometer Testers

- Dynamometer tester must be capable of measuring speed and force at 0 5 second intervals
- Dynamometer testers
  - BAR / Real Time - $450,000, mounted on a trailer
    - Uses wheel on dynamometer to measure speed
    - Uses roll set on dynamometer to simulate a vehicle and measure force applied
    - Measures force through roll set tires, some error in tire/roll interface
  - Sierra Research - $20,000 and brief case size
    - Measures force at dynamometers own load cell
    - Measures speed with photo tachometer

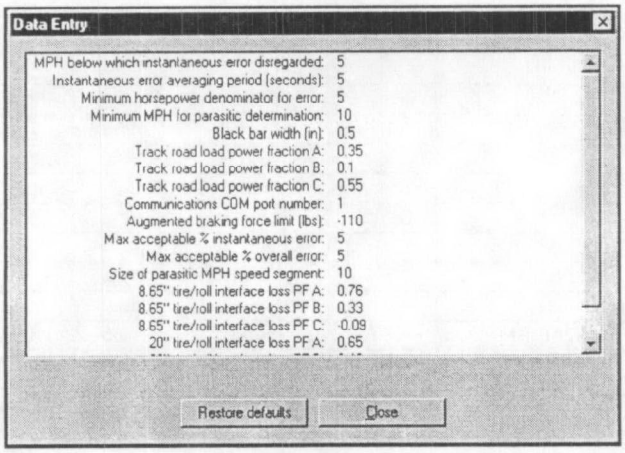
SR Dynamometer Tester



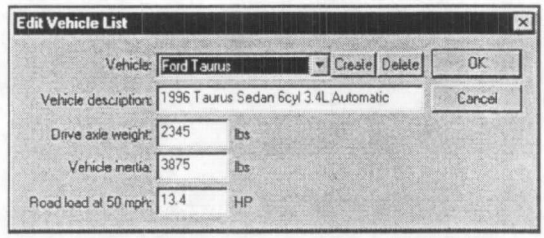
SR Dynamometer Tester Program Main Menu



Configuration Choices



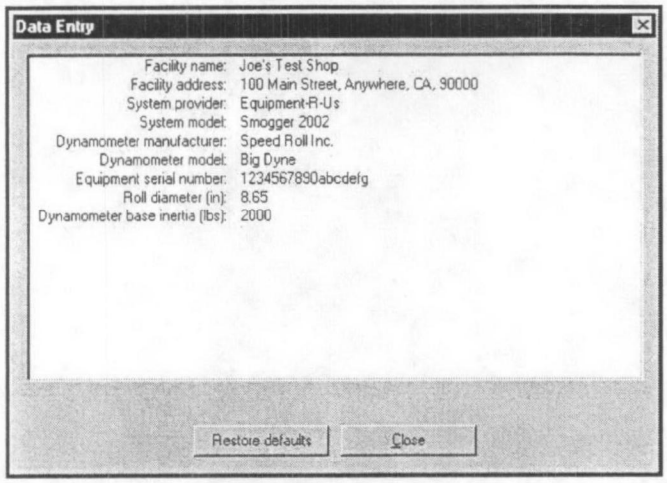
Vehicle List



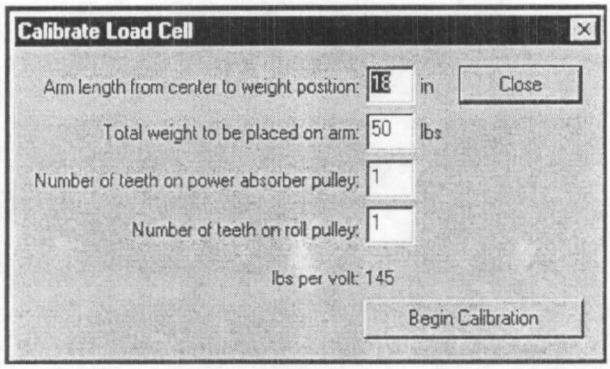
Vehicles Pre-Loaded

"Test" cars	1	2	3	4
VCID	961119	810984	880617	920454
Model Year	1996	1981	1988	1992
Make	Ford	Chevrolet	Yugo	Mercedes
Model	Taurus	K20 Suburban	GV	300TE
Body Style	Sedan	SUV - 4	Sedan	Sedan
Cylinders	6	8	4	6
Engine Size	3.4	5.7	1.1	3.0
Transmission	A	E	M	A
Test Weight	**3875**	**5000**	**2125**	**4250**
TRLHP	**13.4**	**21.0**	**11.1**	**14.8**
Drive Axle Weight	**2345**	**2711**	**1164**	**2000**

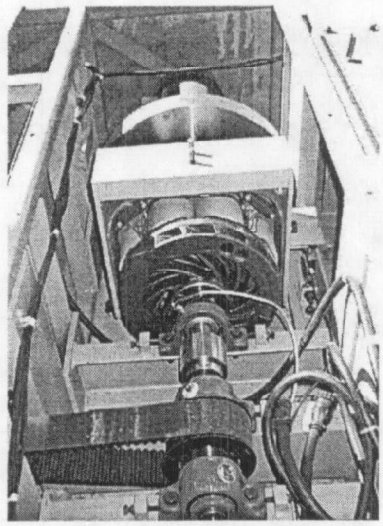
Test Data Entry Screen



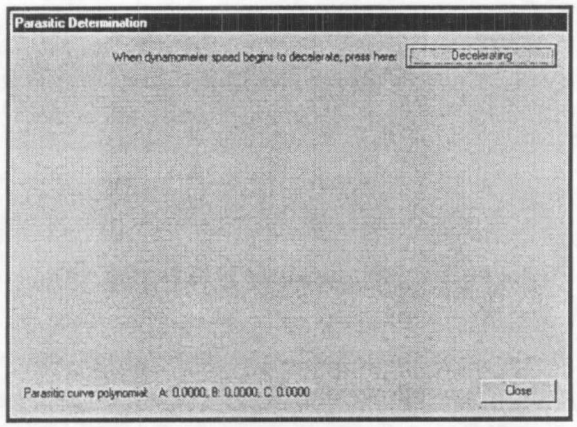
Load Cell Calibration



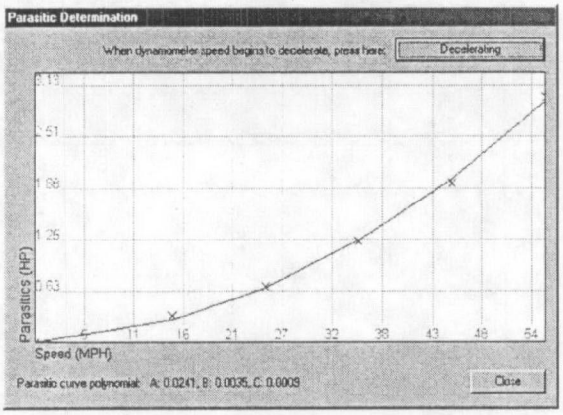
Dynamometer PAU and Load Cell



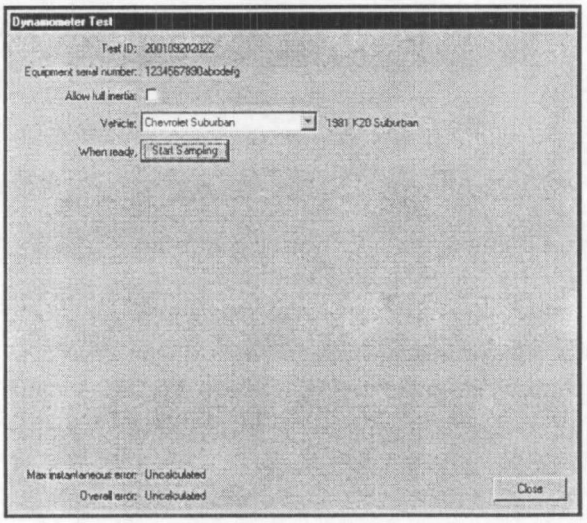
Determine Parasitic Losses



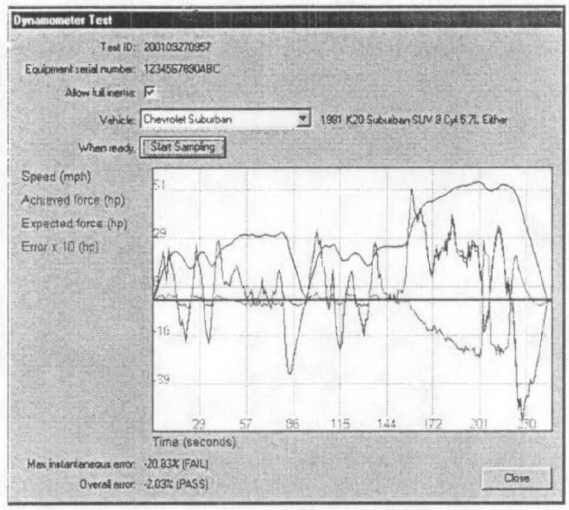
Determine Parasitic Losses



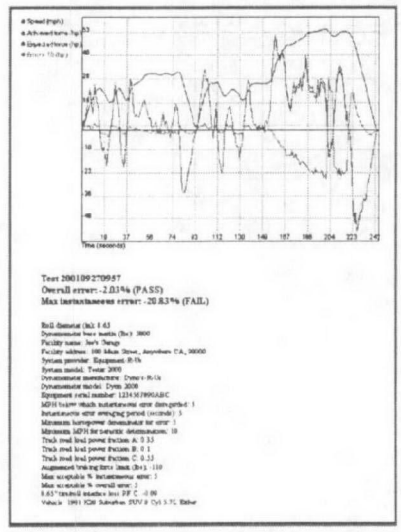
Inertia Simulation Test



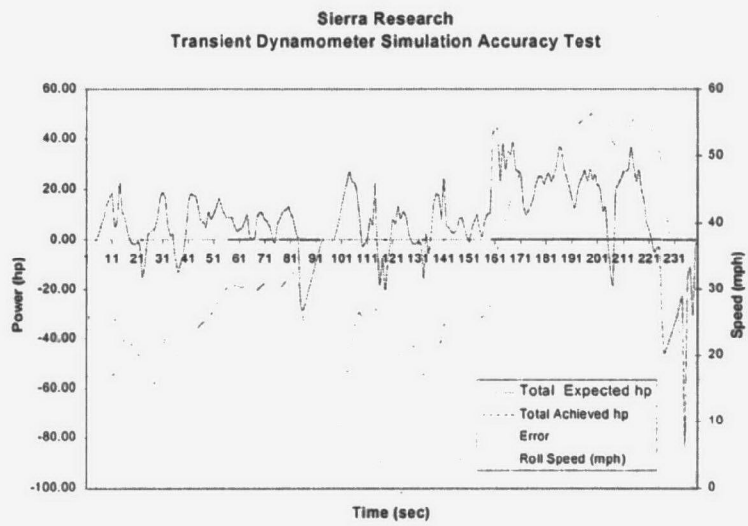
Inertia Simulation Test



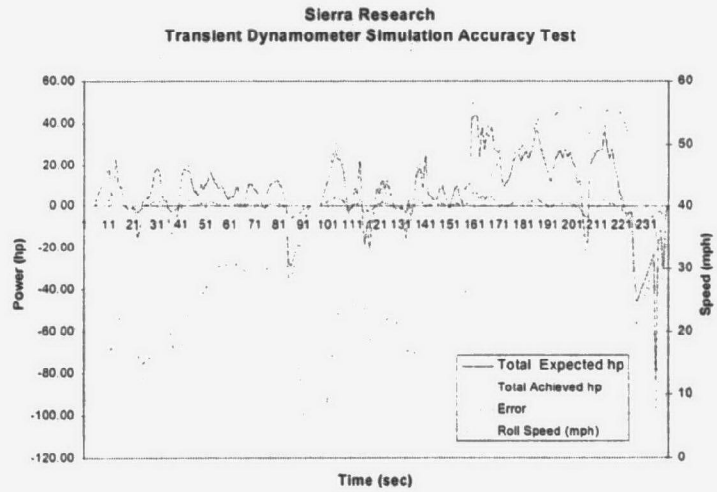
Results Printout



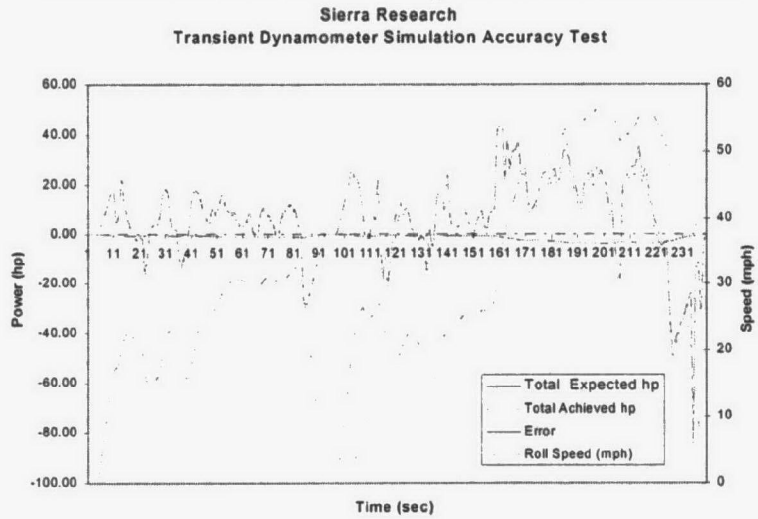
Proper Inertia Simulation



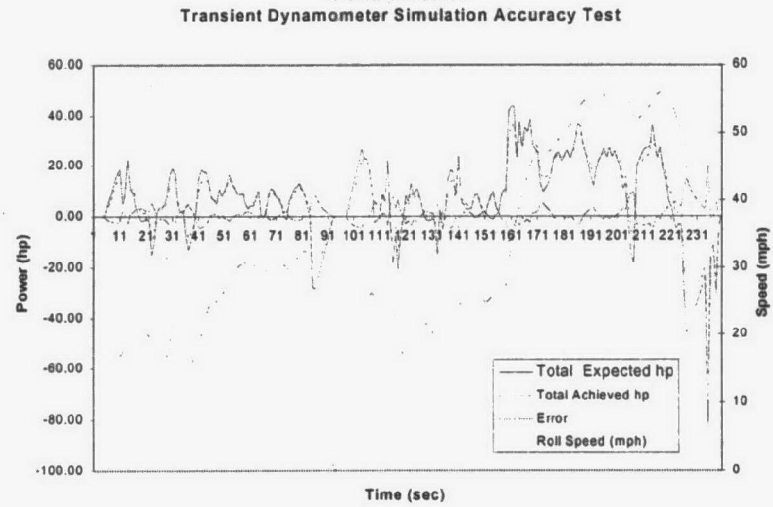
Inertia Setting Incorrect Actual 3000, Set at 5000



TRLHP Incorrect
Should be 15 HP, Set at 12 HP



Dynamometer With a Slow Control System



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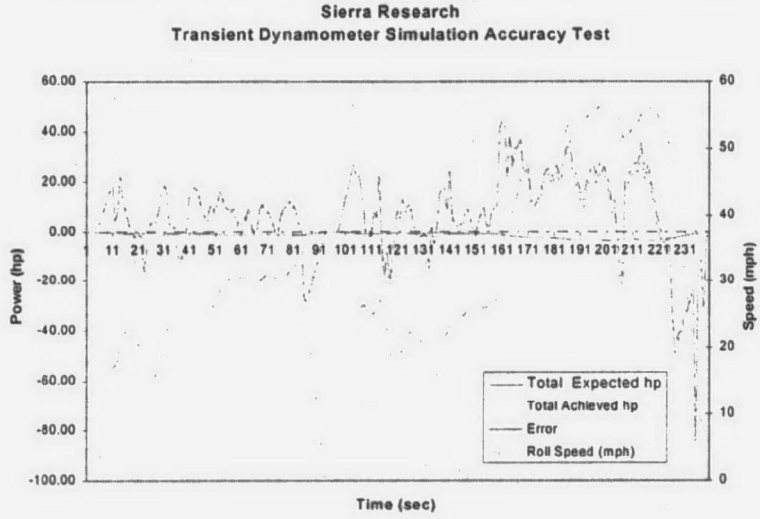


Dynamometer Audit Issues

- Proper error checking of dynamometer load is not incorporated into the control software on some test systems even with disconnected power
- Improper transient loading - "Virtual Inertia"
- No axle weight scales are being used with BAR97 dynamometers in ASM programs
- Roll bearing temperatures are not being checked to compensate for changes in parasitic losses
- BAR97-certified dynamometers are incapable of determining parasitic losses at speeds over 30 mph
- One dynamometer vendor has made changes in the gearing between the power absorption unit and the roll set

Dynamometer ATP Issues

- Problems observed with the use of the EPA/Sierra Lookup Table (ESLT)
  - Some vendors are simply not looking up the vehicle information in the lookup table correctly
  - The second problem is that some locations are not updating the ESLT as frequently as needed, some locations not capable
  - Many testing programs are not using the "by model year" defaults contained in the ESLT
  - Test programs are not maintaining the ESLT vehicle characteristic identification (VCID) number in their databases
- Currently the ESLT only includes the generic tire/roll interface losses for 2WD testing
- In some cases parasitic losses were being subtracted twice (at both the VID and the test system)

6. Gas Cap Tester Audit

- Check gas cap tester accuracy
- Use standard caps (Stant) or wand (Waekon)
- Flow check standards at startup and every six months
- Ensure pass standard is not on analyzer when auditor arrives for audit

Gas Cap Tester Audit Procedure

- Do not calibrate the gas cap tester, test as found
- Put analyzer in gas cap testing mode
- Perform a test with no cap on the tester
- Perform a test with the fail cap on the tester
- Perform a test with the pass cap on the tester
- Record results

Gas Cap Tester Audit Issues

- Currently four types of gas cap testers in use
  - Stant, Waekon, ESP internal, Worldwide internal
  - Some units give unreliable results
- If a gas cap tester fails calibration, stations generally repeat the calibration until passed
- Some calibration procedures do not include checks of the accuracy of the system, but simply reset the calibration point
- Fail standards provided by both Waekon and Stant have on occasion been found to be outside the allowed tolerance
- EPA guidance requires standards are checked before use and at six-month intervals, this is generally not done
- Pass standard used for falsely passing tests

7. Pressure Tester Audit

- Currently not being used, probably will never be used
- Check flow measurement
- Should have volume compensation
- Only prototype testers in NJ
- Only audit tool is in NJ

Pressure Tester Audit Procedure

- Two tank volumes, one for low head space (6 5L), one for large head space (19 5L)
- EPA audit pass/fail limit is a drop of 0.4 inches of water column when pressurized to 28 +/- 1 inch WC
- Tester itself will only pressurize to 14" WC, therefore, a test is needed that can be done at 14"
- Used actual pressure test procedure and look for correct pass/fail result with audit tool set to pass then fail
- Conduct each test at low and high headspace
- NJ pressure tester audit tool orifices are 0 0094" and 0 0142" corresponding to flow rates of 74 6% and 119 1% of the 225cc/min standard

Pressure Tester Audit Equipment

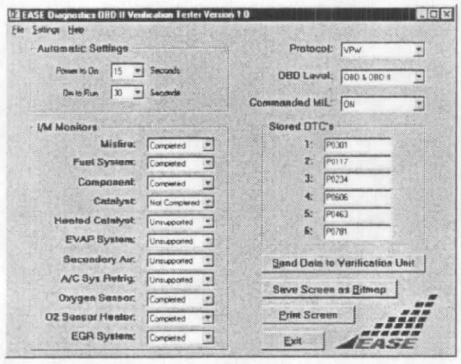
Pressure Tester Audit Issues

- Only decentralized pressure tester designed by Waekon
- Currently there are no decentralized programs conducting pressure testing
- Pressure testing auditing has not been attempted; however, the tool was used during certification testing of the Waekon pressure tester and worked satisfactorily

8. OBDII Tester Audit

- Check the ability of the system to obtain the following over any communication protocol:
  - Readiness monitor status
  - If the MIL is commanded on
  - DTCs set
- Use EASE OBDII Simulator
- PID is set to "FF" so if unit is used for clean scanning, it can be identified from the data stream

OBDII Audit Equipment



OBDII Tester Audit Procedure

- Set the "power on time" and the "time to run" to 15 and 30 seconds
- Randomly choose monitor status (complete, not complete, unsupported) Entering "unsupported" for any of the continuous monitors may cause an error
- Choose communication protocol
- Choose if the MIL is commanded on
- Enter some diagnostic trouble codes (DTCs), they must start with the letter P and be followed by four digits
- Send data to verification unit
- Connect tester to OBDII connector on analyzer and have analyzer poll the unit and report the results

OBDII Tester Audit Calculations

- Check that readiness monitors are correct (complete, not complete, unsupported)
- Is MIL commanded on
- Are all DTC's correctly recorded
- Some states also require the DTC definitions to be displayed or printed on the VIR

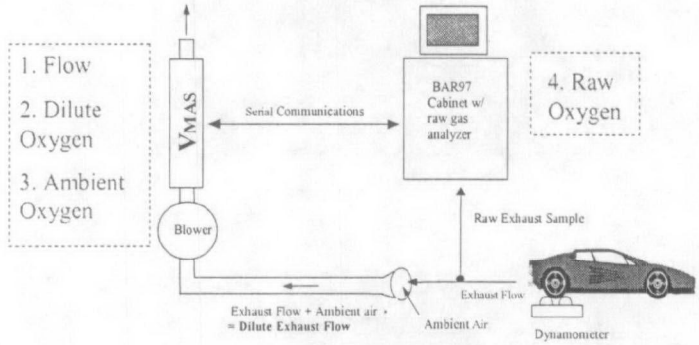
OBDII Tester Audit Issues

- Original simulators did not include Key Word Protocol (KWP)
- Many OBDII test systems did not include the ability to communicate with KWP
- Controller Area Network (CAN) communication protocol to be out in 2003 model year vehicles, current tester does not simulate CAN
- Presently only one manufacturer of the simulator

9. VMAS Audit

- Two measurements to be checked on the Vehicle Mass Analysis System (VMAS) unit
  - Oxygen measurement (used for calculation of dilution)
  - Exhaust flow
- Oxygen sensor on BAR97 analyzer needs to be audited as well

VMAS Unit Operation



VMAS Calculations

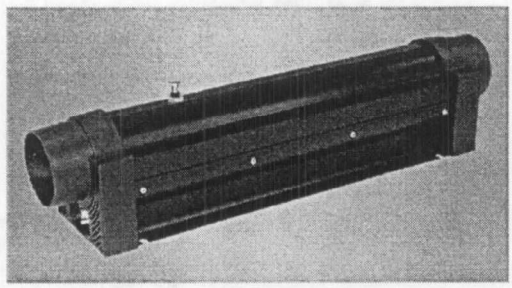
Mass Emission Rate = Dilute flow rate x dilution ratio x concentration

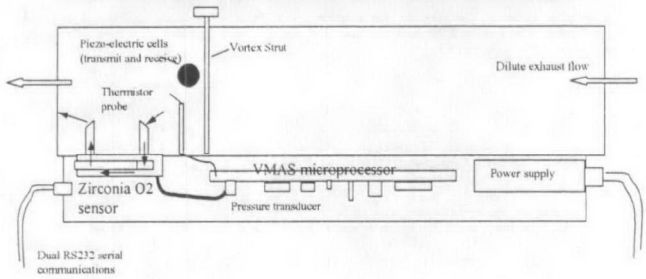
$$\text{Dilution Ratio} = \frac{(\text{ambient } O_2 - \text{dilute } O_2)}{(\text{ambient } O_2 - \text{raw } O_2)}$$

Overflow is when 75% exhaust to 25% make up air is exceeded:

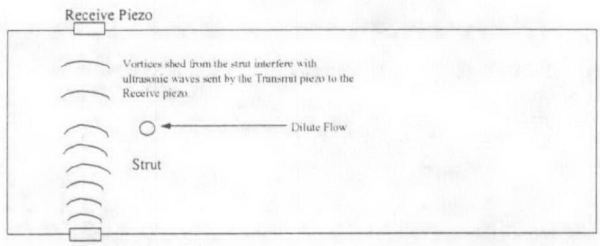
75% exhaust = (calculated exhaust flow / total flow) x 100

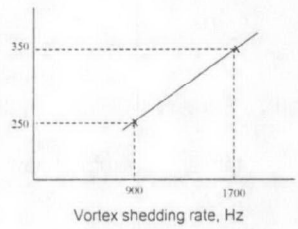
VMAS Unit Components





VMAS Unit Flow Measurement





Technician QC check "Hose-Off" Flow Check

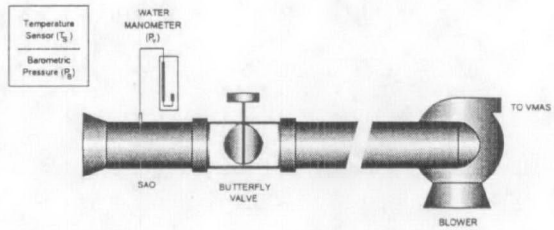
- Compares factory flow rate with hoses removed to current flow rate with hoses removed
- Can be done by technicians weekly
- Requires a screwdriver to remove hoses
- Turn on, allow to flow for one minute, sample flow rate
- Allowable difference is 10%

$$\% \text{ Difference} = 100 \times \frac{\text{Factory hose-off flow rate} - \text{Current hose-off flow rate}}{\text{Factory hose-off flow rate}}$$

VMAS Flow Audit Equipment

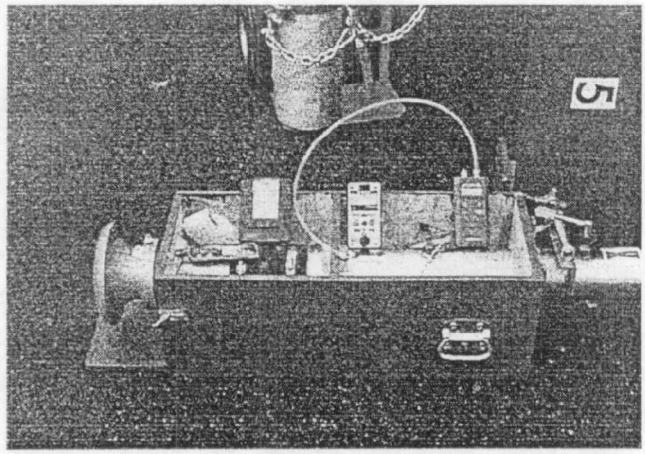
- Smooth Approach Orifice (SAO) with a calibration range of 200 to 500 SCFM
- Barometer
- Manometer
- Thermometer
- Butterfly or gate valve
- Screwdriver

VMAS Flow Audit Equipment - Setup



$$\% \, Difference = 100 \, x \, \frac{SAO - VMAS}{SAO}$$

NY SAO Audit Setup



VMAS Flow Check Audit Procedure

- Remove the hoses from the VMAS
- Place the analyzer in audit mode and display the VMAS flow rate and factory default hose off flow rate
- Perform the hose off flow check
- If the difference between the factory and measure hose off flow checks is more than 10%, have the technician clean the strut and piezos and recheck
- Connect the SAO setup to the VMAS unit, ensure the gate valve is fully open
- Measure the barometric pressure and ambient temperature
- Turn on the VMAS blower
- Record the flow rate displayed at analyzer and pressure at SAO after one minute

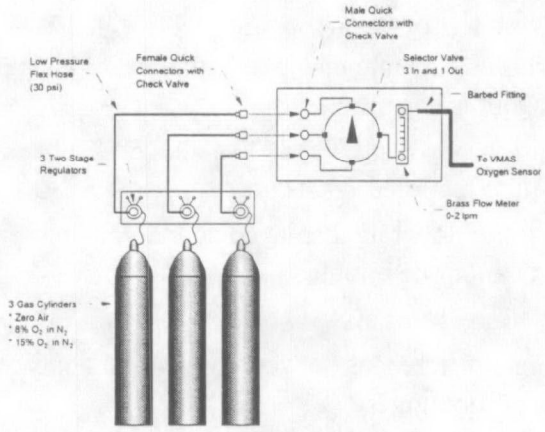
VMAS Flow Check Audit Procedure Continued

- Restrict the flow to 225 CFM indicated on the analyzer
- Record the flow rate displayed at analyzer and pressure at SAO after one minute
- Increase flow to half way between 225 CFM and maximum recorded flow rate
- Record the flow rate displayed at analyzer and pressure at SAO after one minute
- Convert pressures at SAO to flow
- Calculate differences between SAO- and analyzer-indicated flow rates
- Accuracy tolerance is ±10%

VMAS Dilution Audit Equipment

- Zero air
- 8% and 15% oxygen in nitrogen - 1% accuracy gas, 2% blend tolerance
- Three gas regulators for the gas cylinders
- Bubble style flow meter with a 1.5LPM maximum range
- Three position selecting valve with flow meter
- Tygon tubing

VMAS Dilution Audit Equipment - Setup



VMAS Dilution Audit Procedure

- Check accuracy of oxygen sensor in VMAS, oxygen sensor in analyzer was checked in analyzer audit
- Connect audit hardware and connect audit gas to innermost oxygen sensor vent
- Confirm all three gases are set to flow at 1 LPM
- Flow zero air (20 9% oxygen) at 1 LPM
- Enter VMAS audit page
- Turn VMAS and zero oxygen sensor
- Switch to 15% oxygen, flow for 1 minute and record three readings
- Switch to 15% oxygen, flow for 1 minute and record three readings
- Audit tolerances are ± 1 3% at both audit points

VMAS Dilution Audit Tolerances

Spreadsheet for Calculating VMAS Audit Tolerances

Range	Gas	Gas Concentration		Accuracy			Audit Tolerance			Applied Tolerance (greater of % or point)	Audit Limits	
		Recom-mended	Actual Cylinder	% of Reading	Point	Gas	% of Reading	% (as point)	Point		Low	High
Analyzer O2	O2 (%)	1 00	1 01	5 0%	0 10	1 0%	6 0%	0 00	0 11	0 11	0 90	1 12
VMAS O2	High (%)	15 0	14 9	0 3%	0 00	1 0%	1 3%	0 19	0 45	0 45	14 45	15 35
	Low (%)	8 0	7 9	0 3%	0 00	1 0%	1 3%	0 10	0 38	0 38	7 52	8 28

In the "Actual Cylinder" column enter the gas concentrations from the audit cylinders
The audit low and high tolerances are calculated in the columns on the right

VMAS Audit Issues

- No quality control checks for VMAS specified by EPA
- Oxygen sensors in BAR97 analyzers are not required to fail the oxygen sensor quality control check
- Leaking raw probes very important because raw sample oxygen is not dilution corrected and extra oxygen in the raw sample falsely lowers the exhaust flow rate
- VMAS unit oxygen sensor audits failing
- Hose-off flow check for routine inspector QC not implemented, factory values do not exist
- Diluted flow oxygen content on decelerations a problem

VMAS Audit Issues

- There are no QC checks for a dirty strut or piezos
- VMAS calibration considers ambient oxygen 20 8%, not 20 9%
- Oxygen sensor calibrates at a high concentration, measures at lower concentrations Sensors may not be linear in response
- Units may not be calibrated properly before installation
- VMAS mounting could cause low flow. Some stations making holes in hose to avoid low flow lockouts This prevents the overflow lockout from working properly

VMAS Alternative - TransMass™

- Test method developed and patented by Gordon-Darby that allows calculation of mass emissions scores without flow measurement
- IM240 results from Gordon-Darby test lanes used to establish relationships between exhaust volume and vehicle characteristics (e.g., weight and engine size)
- Resulting algorithms applied to test vehicles to compute mass emissions directly from raw tailpipe measurements

TransMass™

- Benefits include:
  - Elimination of flow measurement errors or fraud
  - Potential SIP benefits equal to or greater than ASM (in-progress study)
  - Potential for eliminating ASM-related test problems
- Sierra working with Gordon-Darby on TransMass™ enhancements:
  - Incorporating vehicle emissions simulation model to eliminate total reliance on pre-existing test data
  - Expanding method to include other transient drive traces (e.g., MA31)
  - Investigating SIP credit issue