REGULATION NO. 11

APPENDIX A

(Technical Specifications)

COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT

SPECIFICATIONS FOR COLORADO 94 ANALYZER

HARDWARE SPECIFICATIONS

Revised Sept 09, 1994

Appendix Table of Contents

INTRODUCTION

The Colorado A.I.R. Program is in the process of modifying its current automotive inspection and maintenance program to comply with the Clean Air Amendments of 1990. Colorado's current program is based upon BAR 84 inspection technology utilizing a decentralized program format encompassing nine front range counties. In order to achieve compliance with the Clean Air Amendments of 1990, Colorado will change to a program format that will have a contractor based operation conducting the I/M 240 emissions test and a population of independent inspectors conducting inspections utilizing a new Colo-94 emissions analyzer. The contractor is based in the "enhanced " program area, basically the Denver metropolitan area and will inspect 1982 and newer vehicles. Independent inspection facilities will inspect vehicles of all years within the "basic" program area as well as being able to inspect 1981 and older vehicles within the "enhanced" area.

The demands for more accurate analytical information as well as a more automated inspection process with real-time data transfer has superceeded the capabilities of BAR 84 technology. Current BAR 90 analytical technology is acceptable, but other system enhancements are necessary to meet Colorados inspection needs. These enhancements and other technical details are described in the remainder of this document.

1.0 GENERAL

1.1 Design Goals

The specifications that have been developed are designed utilizing a personal computer system. The analyzer system must be capable of performing uniform and consistent emission tests for Colorado's Automotive Inspection and Readjustment (A.I.R.) Program. Features of the analyzer include: vehicle emissions measurements of hydrocarbon (HC), carbon monoxide (CO), carbon dioxide (CO_2)and oxygen(O_2); engine RPM measurements, exhaust dilution determinations, pressure test system for EVAP; data entry; data retrieval tables; a dedicated printer (for vehicle inspection certificates) and an additional printer for diagnostics and general purpose printouts; data recording on double sided high density 1.44 megabyte (Mb) 3.5" floppy diskette and a 120Mb (or greater) hard drive; modem for "on-line real time" data transmission; CRT information display to the inspector; bar code (2D) reader and printing capabilities; and fully menu driven, interactive simple microprocessor controlled operation.

Additional, automatic features required include: gas calibrations, zero and span checks, pressure calibrations, gas auditing procedure; leak checks, HC hang-up checks, audit menus (i.e., data read system), test sequencing, and low-flow checks. The analyzer shall be designed and constructed to provide reliable and accurate service in the automotive environment. The software used in the analyzer shall consist of a process control system as well as data look-up files. Security shall be provided to prevent unauthorized modifications to the software or test data and recording unauthorized entry (tampering) and locking out of the inspection process when detected.

The emissions analyzer software shall be designed for maximum operational simplicity.

It shall also be capable of providing emission reading characteristics, independent of the inspection function, which can be used for vehicle diagnostic.

1.2 Useful Life

The useful life of the analyzer shall be a minimum of five years.

1.3 Nameplate Data

A nameplate including the following information shall be permanently affixed to the housing of the analyzer:

Name and Address of Manufacturer
Model Description
Serial Number
Date of Assembly

The manufacturer shall affix a stick-on type label to the analyzer which contains a toll-free telephone number for customer service. This number can also be included in a service software message.

1.4 Manuals

Each analyzer shall be delivered with the following manuals:

A. Reference Operating Instructions

B. Operation Instruction Manual

C. Maintenance Instruction Manual (limited)

D. Initial Start-up Instructions

Colorado 94 Analyzer manufacturers may consolidate manuals. The manuals shall be constructed of durable materials and shall not deteriorate as a result of normal use over a five-year period. The analyzer housing shall provide convenient storage for each manual in a manner that will:

E. Allow easy use.

F. Prevent accidental loss or destruction.

1.5 Certification Documentation

The analyzer software shall be fully documented. Two copies of the documentation listed below shall be submitted to the Colorado Department of Public Health and Environment as part of the certification application.

A. Complete program listings. Program listings may be on diskette. <u>They are not required to be submitted with the application for certification.</u>

B. Functional specifications.

C. Functional flowcharts of the software.

D. Example inputs and outputs from all processes.

E. Detailed interface information on system components including the identification of protocol and output specifications.

F. All DOS file layouts with file names, file types, file security, field names, field types, field sizes, and field editing criteria.

Documentation provided by the vendor to meet this requirement will be treated as proprietary information by the Colorado Department of Public Health and Environment.

Prior to certification of any Colorado '94 emissions analyzer for sale in Colorado, the manufacturer of such analyzer shall provide the Division with software source codes and all other technical information (including, but not limited to all working codes, schematics and drawings) necessary to operate, maintain, calibrate and repair such analyzer in the event that the manufacturer or its agent ceases providing adequate maintenance, calibration and repair services in Colorado. The manufacturer shall keep such information current, and will provide the Division with copies of any and all changes. So long as such maintenance, calibration and repair services are available from the manufacturer or its agent, the Division shall protect such information as confidential commercial data if it is clearly marked as such. In the event that the manufacturer becomes insolvent or stops providing adequate maintenance, repair or calibration services in Colorado all such information shall be the property of the Division and may be released to a third party as necessary to repair, calibrate and maintain the analyzers.

1.6 <u>Warranty Coverage</u> / <u>Mandatory Service Contract</u>

A written warranty coverage agreement, signed by an authorized representative of the equipment manufacturer and the vehicle inspection station owner, which provides a complete description of coverage for all systems and components and all manufacturer provided services listed in section 1.8, must accompany the sale or lease of each Colorado 94 emissions analyzer.

An extended service contract must be available upon the expiration of the manufacturers original warranty period. Original manufacturers warranty shall be a minimum of one year from the date of purchase. The "service contract" shall be offered in one year increments and is a mandatory condition of inspection station operation. The "service contract" agreement shall include the inspection station owner's name, inspection station address, telephone number, inspection station identification number, analyzer serial number and detailed terms of the agreement. The agreement must extend for at least one year with the expiration date entered to software file and monitored by the system clock. Approaching expiration messages must be displayed at daily system start-up beginning thirty (30) days prior to expiration and massaging "30 days until expiration, 29 days etc." Failure to renew the "service contract agreement" will cause the analyzer to automatically "lock-out" from any official inspection process. Renewals shall be offered at the inspection station owners request and governed by "good business" practices between the parties involved. Service contract agreements must be available by the manufacturer for the mandated life of the Colorado A.I.R. Program. Cost disclosures and detailed descriptions of coverages must be available in printed form and distributed to all Colorado 94 users. Cost disclosure shall also be made for "consumable" inventory items 1.8B. This information would most appropriately be presented with the original manufactures warranty.

1.7 Tampering Resistance

Controlled access design shall be the responsibility of the manufacturer and is subject to approval by the Colorado Department of Public Health and Environment. Analyzer service personnel, inspectors or others shall be prohibited, to the Colorado Department of Public Health and Environment satisfaction, from creating or changing any test results, programs or data files contained in the analyzer. Manufacturers shall utilize special BIOS partitions, or other appropriate software and hardware provisions, deemed necessary to protect the I/M files and programs. The protection features shall prevent access to the secured floppy disk drive and those portions of the hard disk containing I/M programs and test data or files.

The emission analyzer and the sampling system shall be made tamper-resistant to the Colorado Department of Public Health and Environment satisfaction. At a minimum, the manufacturer shall develop tamper-resistant features to prevent unauthorized access though the cabinet. Microswitches, keyed locks, or software algorithms requiring the use of a password, which can be changed by the Colorado Department of Public Health and Environment would all be acceptable provided the physical or logical design effectively prevents unauthorized access.

Manufacturers may offer analyzers with additional floppy disk drives that can run optional software application programs.

If tampering occurs, a software lockout algorithm shall be activated which aborts any existing test sequence and prevents further inspections until the lockout is cleared by an authorized A.I.R. Program official.

The lockout system shall be designed so that it can be activated by an A.I.R. Program official from the audit menu. Only A.I.R Program Auditors may remove lockouts put in place from the audit menu. Manufacturers shall develop a system by which their service technicians shall be prevented from clearing "tamper" lockouts.

Optional software packages shall not interfere with the normal operation of the I/M inspection and testing software, and shall not compromise the tamper-resistant features of the analyzer.

Manufacturer field service representatives will not have access to DOS, unless assurances acceptable to the Colorado Department of Public Health and Environment have been provided that insure, integrity of the system will not be jeopardized.

1.8 Manufacturer Provided Services

The manufacturer shall agree to provide the following services to the inspection station as part of the manufacturers original warranty and thereafter as a portion of the service contract agreement. The cost of a service agreement is to be listed on a year by year basis. Future charges cannot exceed the amount published.

A. Delivery, installation, calibration, and verification of the proper operating condition of a Colorado 94 emissions analyzer.

B. Quarterly (90 days) examination, calibration, and routine maintenance of the analyzer and sampling systems. Full systems support and repair, including loaner units. Upon initial sale or loan, provide "extra" printer medium (1 ea.) sample filter(s)(2), sample hose(1) and sample probes (1). Maintain the "extra" consumable inventory upon examination and provide a software history file for the replacement of consumables accessible to A.I.R. Program officials. Consumables and the cost(s) there of must be disclosed in the service agreement.

C. Instruct all certified inspectors employed by the inspection station at the time of installation in the proper use, maintenance, and operation of the analyzer. The analyzer shall contain a feature that will allow an inspector to go through the complete inspection procedure without generating an official inspection record. This function will be used for evaluating inspector performance, by A.I.R. Program officials, or by the manufacturer for demonstration purposes. The "training mode" shall not require the use of an inspectors access code or allow access to secured areas of hardware or software. The display shall show a message throughout the inspection that this is not an official inspection. Vehicle inspection reports shall indicate to the satisfaction of the Colorado Department of Public Helath and Environment that they are for training only. No official Certificate of Compliance will be generated during the training exercise.

D. On-site service response by a qualified repair technician within two (2) business days, (48 hours) excluding Sundays and national holidays, of a request from the inspection station. The names, toll-free telephone numbers, and service facility addresses of all manufacturer representatives responsible for equipment service shall be provided to the inspection station. A service representative shall be available at all times during normal working hours. Sundays and national holidays are not included. All system repairs, component replacements, and/or analyzer adjustments, shall be accomplished on-site within 48 hours after a service request has been initiated. If the completion of this work is not possible within this time period, a Colorado 94 loaner unit shall be provided until the malfunctioning unit is properly repaired and returned to service. Service representatives shall have a software driven menu option that allows the transfer of inspection station, inspector information and other applicable data files from one analyzer to another without manual inputs and without transfer of previous test files.

E. Updates of the "Functional" software will be limited to once per year at no cost.

Updates of operational software i.e., file based information will be on a "as required" basis. All forms of software updating will utilize modem technology for the updating process. File updates are at no cost and every effort will be made to minimize them.

F. The analyzer software shall be designed so that A.I.R. Program officials can insert a floppy disk, prepared by the manufacturer, into the Program system host, and update the existing software version, via modem. A system of manual updating by program officials utilizing the auditors menu shall also be available. Look-up tables and message screens shall be designed sufficiently separate from the main operations software so that it is not possible,to interfere in any way with the operations of the analyzer.

The Colorado Department of Public Health and Environment will require the manufacturer to render updates as necessary in the first year of the program to ensure the program meets all design criteria. Thereafter software updates will be limited to once per year at no cost. Since modem software updating will be utilized, there are no costs to the analyzer owner. A software version number, consisting of a four character alpha-numeric code made up of the last two digits of the year followed by a two character version number, shall be recorded in the analyzer and included on each vehicle test record. The analyzer manufacturer shall not modify any existing software version without obtaining written approval from the Colorado Department of Public Health and Environment.

The Colorado Department of Public Health and Environment may require the manufacturers to conduct on-site or laboratory testing of in-use analyzers in order to document continued compliance. When an analyzer is removed from the field, for repair or testing, manufacturers shall supply the inspection station from which it was removed with a temporary replacement unit meeting all program requirements. Manufacturers shall pay for all necessary shipping and transfer costs for the replacement of the analyzer selected for compliance testing. Manufacturers shall also pay for any required testing performed by their personnel or by an independent company.

The manufacturers shall provide training to A.I.R. Program officials on all operational, maintenance, and quality control features of the analyzers, including full access to and use of inspection menus, audit menus and calibration menus, as well as optional programs offered to inspectors. Such training shall be conducted at the manufacturer's expense as a condition of certification and thereafter at reasonable intervals upon written request by the Colorado Department of Public Health and Environment

1.9 Certification Requirements

The manufacturer shall submit a formal certificate to the Colorado Department of Public Health and Environment that states that any analyzer sold or leased by the manufacturer or its authorized representatives for use in the Colorado A.I.R Program will satisfy all design and performance criteria described in these specifications. The manufacturer shall also provide sufficient documentation to demonstrate conformance with these criteria including a complete description of all hardware components, the results of appropriate performance testing, and a point-by-point response to specific requirements. Previous certification by the California Bureau of Automotive Repair (BAR) is necessary for the analytical bench.

In addition, a full description of the company's service procedures and policies, as well as sample contracts, warranties, and extended service agreements, shall be provided as part of the certification application to ensure proper maintenance of all analyzers throughout their useful life. One fully functional analyzer shall be presented for evaluation and one additional fully functional analyzer for the certification process. If certified these units will remain in A.I.R. Program possession for continued in-use evaluation for the life of the A.I.R. Program. In the event that 1% of overall unit sales exceeds this two unit base, in-use evaluation will require 1% of overall unit sales for in use evaluation.

2.0 CONSTRUCTION DESIGN

2.1 Materials

All materials used in the fabrication of the analyzer and the appropriate housing assembly shall be new and of industrial quality and durability. Contact between non-ferrous and ferrous metals shall be avoided where possible. Suitable protective coatings shall be applied where galvanic action is likely. All mechanical fasteners shall have appropriate locking features. Use of self-tapping screws shall be limited. All parts subject to adjustment or removal and reinstallation shall not be permanently deformed by the adjustment or removal-reinstallation process and this process shall not cause deformations to adjoining parts. Only materials that are not susceptible to deterioration when in contact with automobile exhaust gases shall be used.

2.2 Construction

The analyzer shall be complete and all necessary parts and equipment required for satisfactory operation shall be furnished. A suitable means of storing the probes and sample hose shall be provided. A means of storing the "spares" inventory shall be included. All parts shall be manufactured and assembled to permit the replacement and/or adjustment of components and parts without requiring the modification of any parts or the basic equipment design. Where practical, components and/or subassemblies shall be modularized. The analyzer cabinet finish shall be baked enamel or another durable finish.

2.3 Mobility

The analyzer unit shall be designed for easy and safe movement over rough surfaces and/or graded surfaces (15° incline). The center of gravity and wheel design shall be such that the analyzer can negotiate a vertical grade separation of one-half inch (1/2") without overturning when being moved in a prescribed manner. Industrial grade, swivel casters shall be used to permit 360° rotation of the unit. The caster wheels shall be equipped with oil resistant tires and foot operated brakes capable of preventing movement on a 15° incline.

2.4 Electrical Materials/Construction

Unless otherwise specified, all electrical components and wiring shall conform to standards established by the Underwriters Laboratories, Standard for Electrical and Electronic Measuring and Testing Equipment (U.L.-1244).

The analyzer shall operate from a 115VAC, 60 hertz (Hz) supply. An input voltage variation of $\pm$12 volts shall not change analyzer performance more than 1% of full scale. The analyzer must operate on a 15 AMP breaker. The power cable shall be equipped with a standard three-prong connector at the inlet, and shall have a National Electrical Code rating of SO, SJO or better with an overall length not to exceed 25 feet. Each emissions analyzer shall incorporate safety devices to prevent conditions hazardous to personnel or detrimental to equipment. The system shall be grounded to prevent electrical shock, and adequate circuit overload protection shall be provided. The analyzer shall incorporate an internal surge protector.

2.5 Sampling System

The sampling system consists of two subsystems: (1) external sampling system; and (2) internal sampling system. The external system shall include a sample probe, sample hose twenty-five feet (25') in length, a water trap, and a filtration system. The internal subsystem shall include but not necessarily be limited to, a sample pump and bypass pump, or an equivalent system approved by the Colorado Department of Public Health and Environment.

The sample probe shall incorporate a positive means of retention to prevent it from slipping out of the tailpipe when in use. A thermally insulated, securely attached hand grip shall be provided on the probe in such a manner that easy probe insertion using one hand is ensured.

The probe shall also have a smooth surface near the probe tip before the flexible portion of the probe to be used for sealing of the span gas adaptor necessary for field or on-board leak checking (vacuum or gas) or response time checking equipment. For standardization, it is recommended that the sealing surface be one-half inch (1/2") in outside diameter and one-half to one inch (1/2" to 1") long. A probe tip cap shall be provided for the sample system leak check. A probe tip adapter or assembly shall be included for use with spark arrester type tail pipes.

The interconnecting hose shall be of such design and weight that it can easily be handled by the inspector. The hose shall be of non-kinking construction and fabricated of materials that will not be affected by or react with the exhaust gases. Molecular HC hang-up shall be minimized. The hose connection to the analyzer shall be reinforced at the point of maximum bending. The system shall be designed with a water trap in the bypass sample stream. The water trap shall be continually self-draining. The trap bowl shall be constructed of a durable transparent material. The water trap should be located as low as possible on the analyzer so that condensed water in the sample hose will drain into them. However, the trap must be placed in a position readily visible to the inspector. The sample for the analyzer shall be obtained from the top of the water trap. The sampling system shall be equipped with a suitable particulate filter upstream of the optical bench. There may be a secondary filter located in the sample hose, serviceable by the inspector. This filter must have sufficient capacity to filter the samples obtained during the routine testing of vehicles in the inspection station. Threaded connections must be used to attach the filter to the sample hose. A prompt shall be provided to the inspector indicating when the filter should be changed based on an indication of low flow (automatic lock-out) or other criteria approved by the Colorado Department of Public Health and Environment

The pumps shall contain corrosion resistant internal surfaces. The pumps shall have a minimum operational life of 2,000 hours without failure.

The sample pump system may be either a single pump, multiple pumps, or a multiple stage pump or an equivalent system approved by the Colorado Department of Public Health and Environment. The sample pump shall have integral motor overload protection and be permanently lubricated. The bypass system shall be connected in the sample system so that any water condensed in the water trap is removed and dumped outside the system.

2.6 Storage Temperature

While in storage, the analyzer and all components thereof shall be undamaged from ambient air temperatures ranging from 0° F to 120° F.

2.7 Operating Temperature

The analyzer and all components shall operate within calibration limits in ambient air temperatures ranging from 41° F to 110° F.

2.8 Humidity Conditions

The analyzer shall be designed for use inside a building that is vented or open to outside ambient humidity. The analyzer, including all components of the analytical, sampling, and computer systems, shall operate within the required performance specifications at ambient conditions of up to 80% percent noncondensing relative humidity throughout the required temperature range, assuming the components are reasonably protected by the inspector from direct contact with water, or other condensing moisture. Failure of any component due to exposure to temperature and humidity extremes within the limits specified during actual use shall be corrected at the manufacturer's expense.

2.8.1 Temperature Control

Analyzer components which affect sensitivity and calibration shall have their internal temperatures controlled to maintain design temperature, when exposed to prevailing ambient conditions. If internal operating temperatures are exceeded the analyzer will automatically lock-out from any official inspection process.

2.9 Barometric Pressure Compensation

Barometric pressure compensation shall be provided. Compensation shall be made for elevations up to 6,000 feet (mean sea level). At any given altitude and temperature, errors due to barometric pressure changes of ± two inches (2") of mercury shall not exceed the accuracy limits specified in this specification. Manufacturers shall describe in writing how compensation will be accomplished. The method used shall be acceptable if approved by the Colorado Department of Public Health and Environment.

2.10 Operational Design

A. Analytical System

These analyzers shall utilize nondispersive infrared systems for measuring hydrocarbons (HC), carbon monoxide (CO), carbon dioxide (CO_2). Oxygen (O_2) shall also be measured and ambient air will be used for calibration purposes.

B. Readout Display/CRT Screen

The screen shall contain numerical HC (as hexane), CO, CO_2 and O_2 displays and a pass/fail indication at the completion of the inspection process. Pressure purge shall be a pass/fail indication, with pressure/time values recorded to file.

The numerical display shall be of a digital format. The resolution of the emissions display shall be as follows:

HC:	XXXX ppm (as hexane)
CO:	XX.XX%
CO_2:	XX.X%
O_2:	XX.X%

The **MINIMUM** display increments shall be 1 ppm HC, 0.01% CO, 0.1% CO_2, and 0.1% O_2. The displays shall be capable of full scale readings of 2000 ppm HC (as hexane), 9.99% CO, 16.0% CO_2 and 25.0% O_2.

CRT display is to be employed for an exhaust sample validity (sample dilution). This indication will signal excess dilution in the exhaust system based upon measurement of CO + CO_2 emissions.

The analyzer shall be capable of selecting the pass/fail values (limits) based on vehicle model year, vehicle type, or other criteria. The system shall be designed in such a manner that the standards and vehicle groups may be readily revised by a modem software update.
Specific emissions limits and vehicle model year groupings are available in this Regulation NO.11, part F: maximum allowable emissions limits for motor vehicle exhaust, evaporative and visible emissions for Light-Duty and Heavy-Duty vehicles.

2.11 Automatic Calibrations

The analyzer shall be designed to require an automatic two point gas calibration for HC, CO, and CO_2, and an automatic electrical zero and span check. (O_2 shall be measured by ambient air.) The automatic gas calibration shall be conducted every 24 or 72 hours, activated by the internal clock. The option of 24 HOUR calibration will be software selectable, with the default @ 72 hours. Electrical zero and span check (automatic) shall be required prior to each test sequence. User friendly prompts shall be provided to the inspector to indicate every step needed to properly perform the required gas calibration (including when it is necessary to turn the gas cylinder valve on and off).

If the system is not calibrated, or the system fails the calibration or the zero and span check, an error message or fault indication shall be displayed and the analyzer shall be locked out to prevent the performance of an emissions inspection. Lock-out will remain until the system is properly calibrated and passes a calibration\leak check and zero and span check.

The calibration record will contain before and after calibration readings. The gas calibration shall ensure that accuracy specifications are satisfied and that linearity is correct at the required span points. The gas calibration and leak check procedures shall require no more than five (5) minutes to complete. The analyzer shall provide adequate prompts on the display to guide the inspector through the calibration procedure in a manner that minimizes the amount of calibration gas used.

The system shall have the capability of printing historical calibration data for specified date ranges by the A.I.R Program Auditor. (Audit menu, calibration history)

For HC, CO and CO_2, analyzer manufacturers shall limit gas usage during the gas calibration procedure to two liters per point. The analyzer shall also be designed to keep the loss of calibration gas to a absolute minimum (less than 0.5 liters in 24 hours) if the calibration gas valve(s) is/are not shut off. Manufacturers shall provide an evaluation of this capability, consisting of at least four (4) analyzers, with their certification application materials and shall demonstrate this feature during certification.

The analyzer shall be equipped with a gas calibration port for the purpose of performing a probe to calibration port comparison for audit purposes. Gas auditing shall be accomplished by introducing standard gases into the analyzer either through the calibration port or through the probe. Span gases utilized for calibration shall be within two percent (2%) of the following points: Ambient air may be used to calibrate the O_2 sensor.

(HC)	300	ppm propane
	1.0	% carbon monoxide (CO)
	6.0	% carbon monoxide (CO_2)
	Bal.	Nitrogen (N_2)
(HC)	1200	ppm propane
	4.0	% carbon monoxide (CO)
	12.0	% carbon monoxide (CO_2)
	Bal.	Nitrogen (N_2)

The standard gases used to calibrate, and audit the analyzers shall satisfy the criteria included in the Federal Clean Air Act, section 207 (b) and described in Subpart W of Part 85 of Chapter I, Title 40 of the Code of Federal Regulations. In order to ensure that the quality of the standard gases used in the program meet these specifications, all standard gases purchased by the inspection facility for use in the analyzer must conform to the requirements established in 1990 by the California BAR for Test Analyzer System Calibration Gases. Calibration gases must be purchased from a vendor which has Colorado gas blender certification, REF. Colorado Regulation No.11, Appendix B. These requirements include the testing and certification of the concentration, accuracy, precision, and purity of the standard gases to within the referenced limits and the labeling of individual gas canisters describing these and other specified parameters.

Automatic EVAP Pressure Calibration

The pressure test system is to be calibrated every 24 or 72 hours and zero/span checked before each inspection. Pressure calibration checks should be performed simultaneously with the gas calibration procedure. Calibration and/or zero span checks must pass or the analyzer must lock-out from further testing until the discrepancies are corrected. All calibrations will be stored to the Cal.Dat Dat file. Pressure system calibrations shall be performed in a maximum time period of 5 minutes, calculated independently from the gas calibration and leak check. The optional 24 hour option shall be selectable and defaulted to 72 hours.

A. Automatic Leak Check

An automatic leak checking system shall be provided that will allow the vacuum side of the system to be checked for leakage. Appropriate valves lines, and switches shall be installed to permit this operation. Minimal activity by the inspector, such as setting the probe in a holder or capping the probe, is permitted, provided errors resulting from improper inspector action would be identified by the computer and would require corrective actions. Improper action would cause the system to fail a leak check, and automatically lock-out. User friendly prompts shall be provided to the inspector to indicate every step needed to properly perform the required leak check (including when it is necessary to turn the gas cylinder valve on and off).

A system leak check shall be accomplished every 4 or 24 hours and in conjunction with the gas calibration performed every 24/72 hours, activated by the internal clock. The 4 hour option shall be software selectable with the 24 hours as the default value. Four hour leak checks are required only for those facilities performing more than 4000 inspections per year. The analyzer shall not allow an error of more than $\pm$3% of reading using mid-range Colorado certified span gas to perform the leak check. Fittings and connectors used on the sample hose and probe shall be constructed to inhibit the bypass of the leak check. A maximum of two liters of calibration gas may be used to perform the leak check. If the system is not leak checked, or the system fails a leak check, an error message or fault indication shall be displayed, and the analyzer will be locked out to prevent the performance of an emission inspection, until the system is properly leak checked and passes.

B. Automatic HC Hang-Up Check

The analyzer shall be designed for using ambient air induced through the sample probe, prior to each test sequence. The analyzer shall have a CRT prompt/indicator. "Hang-up" activation shall cause the analyzer to automatically sample ambient air through the sample line and probe. The system shall continue to sample room air for a maximum of ***150*** seconds or until the HC response is below 20 ppm hexane.

If the HC hang-up does not drop below 20 ppm within ***150*** seconds, a message shall be displayed indicating possible dirty filters or sample line. If after ***150*** seconds HC levels are not below specified values, the test shall be discontinued until HC hang-up is corrected. When the level stabilizes below this value, an indication that testing may begin shall be displayed. The analyzer shall be locked out from operating until the HC level is met.

C. Vehicle Diagnostics

During analyzer warm-up, emissions diagnostics and other gas reading functions shall be prohibited. After successful warm-up and for the purpose of vehicle diagnosis or repairs, the analyzer shall have a menu selection, that will allow the analyzer to continuously monitor the vehicle exhaust.

The automatic data collection system shall be prevented from operating anytime the analyzer is not being used in the official emissions inspection mode.

D. Dilution

The analyzer manufacturer shall document to the satisfaction of the Colorado Department of Public health and Evnironment that the flow rate on the analyzer shall not cause more than 10% dilution during sampling of the exhaust at normal idle (10% dilution defined as sample of 90% exhaust and 10% ambient air). Manufacturers shall utilize the procedures specified by the BAR for demonstrating this dilution criteria.

The analyzer shall be equipped with a feature to identify vehicle exhaust system leaks and sample dilution. The preferred method for identifying leaks is monitoring the CO & CO_2 levels in the exhaust. Other additional techniques that can demonstrate improved sensitivity to leaks may also be used.

DILUTION VALUES:

All light duty vehicles: 6%
All heavy duty vehicles: 5%

If the CO + CO_2 reading is less than the limit, the inspector shall be prompted to check the exhaust system for leaks and to make sure that the sample probe is all the way into the tailpipe. If the excessive dilution is detected after the initiation of the test sequence, the analyzer output shall display "SAMPLE DILUTION". If dilution continues the inspector shall be required to "Abort Test". The system shall store the "Abort Test" indication.

E. Engine Tachometer

A digital display tachometer shall be CRT displayed for the purpose of measuring engine speed. The tachometer operation shall be by two means; (1) a radio frequency "RF" type transmitter/receiver that requires no direct vehicle connection and can detect engine RPM on vehicles utilizing "DIS" systems. (2) a cable type connection capable of detecting engine RPM from all forms of current O.E.M. ignition technology. Tachometer performance shall be no less than; RPM with a 0.5 second response time and an accuracy of ±3.0% of actual RPM. During an official inspection process, the software will prompt the inspector to shut the engine off while connecting the RPM probe (only if a cable connection is being made). A software "HELP" screen will be available to assist the inspector in locating an RPM signal. This information may be supplied or reviewed by the Colorado Department of Public Health and Environment. Based on the vehicle identification information available to the inspector, the analyzer will prompt the inspector as to which vehicles require a specific type or method of connection of the tachometer pick-up. Analyzers shall be provided with all the software and hardware that is necessary to make them capable of reading engine RPM from all O.E.M. ignition technologies in use at the time of certification. Possible updates may be required to enable future ignition systems to be monitored for engine RPM.

F. Analytical Bench Accuracy

Each analyzer shall meet the following analytical accuracy requirement:

Channel	Range	Accruacy

HC ppm	0-400	±12 ppm
	401-1000	±30 ppm
	1001-2000	±80 ppm
CO%	0-2.00	±0.15 %
	2.01-5.00	±.040%
CO_2%	04.0%	±0.6
	4.1-14.0	±0.5%
	14.1-16.0	±0.6%
02%	0-10.0	±0.5%
	0-10	±1.3%

The analyzer display resolution electronics shall have sufficient resolution and accuracy to achieve the following:

HC	1 ppm	HC
CO	0.01%	CO
CO_2	0.1%	CO_2
O_2	0.1%	O_2

G. Drift

If zero and/or calibration drift cause the infrared signal levels to move beyond the adjustment range of the analyzer, the inspector shall be locked out from testing and instructed to call for service.

H. Warm-Up

The analyzer shall reach stabilized operation in an inspection station environment within 15 minutes at ^{0} 41 degrees Fahrenheit from "power on". The instrument shall be considered "warmed-up" when the zero and span readings for HC, CO, and CO_2 have stabilized, within ± 3% of full range of low scale, for five minutes without adjustment.

Functional operation of the gas sampling unit shall remain disabled through a system lockout until the instrument meets stability and warm-up requirements. If the analyzer does not achieve stability with 15 minutes, from "power-on", it shall be locked out from I/M testing and a message shall be displayed instructing the inspector to call for service.

During the warm-up, the Main Menu shall be displayed unless an optional functional menu or menus are offered. The analyzer system shall lock out all bench related functions during warm-up. During warm-up, a message under the main menu shall be prominently displayed as follows: "Warm-up in progress - checking for stability". During the initial entry into the "warm-up" period, and before any other menu can be selected, the software will automatically enter a "bulletin display" function and display any messages or bulletins forwarded from the A.I.R. Program host system via modem transfer in the past 72 hours. This screen will reference the inspector.dat file and require each inspector to enter their access code as verification of receipt, before allowing that inspector to Proceed with an inspection. No inspector can enter into an official inspection without having "logged on" as having seen the Bulletin screen. When stability is achieved and the warm-up requirements are satisfied, access to gas bench functions shall be permitted.

I. System Response Time Requirements

The response time from the probe to the display shall not exceed eight (8) seconds to 90% of a step change in input, nor will it exceed 12 seconds to 95% of a step change in input. For the O_2 sensor, the response time shall be no more than fifteen (15) seconds to 90% of full scale.

J. Optical Correction Factors

The hexane/propane equivalency factor (PEF) shall be limited to values between 0.49 and 0.52. If an optical bench is used that can demonstrate accuracy of propane/hexane identification within specification, using a range greater or lessor than indicated, it will be considered. Factor confirmation shall be made on each analyzer assembly by measuring both N-hexane and propane on assembly line quality checks. The PEF shall be permanently stored in non-volatile memory. The PEF shall be displayed on the monitor on request by inquiry through the menu system. The optical bench shall be marked with a permanent "stamped" type tag identifying its P.E.F..

The signal strength from the source to the detector for all channels shall be monitored such that when the signal degrades beyond the adjustment range of the analyzer, the analyzer shall be locked out from operation, i.e. fail calibration.

K. Interference Effects

The effect of extraneous gas interference on the HC, CO, and CO_2 analyzers shall not exceed $\pm$10 ppm HC, $\pm$0.05% CO, and $\pm$0.20% for CO_2.

The instrument design shall insure that readings do not vary as a result of electromagnetic radiation and induction devices normally found in the inspection environment (including high energy vehicle ignition systems, RF transmission radiation sources, and building electrical systems). In addition, the manufacturer shall ensure that the analyzer processor and memory components are sufficiently protected to prevent the loss of programs and test records.

2.12 Gas Calibration File

At the conclusion of each gas calibration the required data shall be placed in the CAL.DAT file.

2.13 Microcomputer Specifications

A. A standard microcomputer must be included in the analyzer and is to be used to control all analyzer functions. Each vendor is to develop DOS executable programs for each required function. These programs shall:

1. control each of the analyzer functions and time of function;

2. examine and obtain values from all of the analyzer sensors;

3. read and write information to diskette in standard DOS format; and

4. copy the analyzer, inspection station identification information from the hard disk onto each new floppy diskette when formatted.

The Colorado Department of Public Health and Environment reserves the right to add additional programs and functional performance requirements, up to the technical limits of the hardware, to improve the I/M program.

Sufficient flexibility shall be provided in the design of the microcomputer system to allow expansion of the analyzer to include, but not be limited to, the following additional capabilities:

1. connect and recover data from vehicle on-board diagnostic systems (OBD) meeting SAE specifications when they become available;

2. monitor vehicle recall data; identify, record and process data as required when an official EPA/SAE format is identified.

3. accommodate additional input channels in both analog and digital form. Two free slots, 16 bit capability.

The manufacturer may offer additional features which utilize the microcomputer as a stand-alone personal computer by providing optional software to perform various non-I/M functions. Such offerings must not interfere with the inspection requirements, nor in any manner affect or allow the inspector to tamper with the inspection-related computer programming or data files.

The analyzer shall be equipped with an internal clock which operates independently from the power source and will provide accurate and automatic date and time information for the following functions:

a. each test performed;

b. automatic gas calibration and pressure test check (72 hours); (24 hour) optional

c. automatic leak check (4 or 24 hours and every 24/72 hours for automatic gas calibration), and leak check combination.

d. audit sequence:

All equipment and software submitted for Colorado certification must be the full and current configuration proposed for sale. Partial, dated, or incomplete models are not acceptable.

Acceptance of the microcomputer portion of the Colorado 94 Analyzer system will be dependent upon the satisfactory performance of the full proposed configuration meeting all the requirements of this specification.

The proposed hardware configuration must be fully supported by all software and/or operating systems listed in the acceptance requirements or elsewhere in these specifications. Performance tests to prove compatibility will be conducted. The vendor will bear all shipping and equipment preparation charges for the certification testing.

2.14 Standard Hardware: Minimum Required Configuration

1. Operating System

DOS Version 6.2 or most current

2. Processor

The microprocessor must be fully compatible with the Intel 80486 microprocessor. Upgradable to Pentium technology.

3. RAM Memory

The system must contain at least 2 MB of user available RAM. (expandable to 16 MB)

4. Power Up Sequence

The system must include a power up sequence which provides a self-diagnostic routine to check the on-line presence of critical PC components (including, at a minimum, the processor, firmware ROM, hard disk controller, keyboard, clock, modem, printers, bar code reader I/O ports, setup RAM and memory).

5. Video

The CRT display must be at least 12" in diagonal measure and operate in a VGA mode.

The software shall automatically blank the screen or use a screen saver mode, if no keyboard entry is made for 10 minutes. The display shall return when the inspector strikes any key.

6. Floppy Disk

Each unit must come with an IBM compatible floppy disk drive which will permit full usage of 2sHD 1.44 Mb 3.5" removable media. The drive must be located in a secured area accessible only to authorized A.I.R Program Service representatives. That secured drive must also include an approved method to limit logical access. Colorado Department of Public Health and Environment will test the system for drive security and it should not provide access to the secured floppy except through the approved security procedure. The secured floppy drive shall be designated the "A" drive.

7. Hard Disk

Each unit must come with at least 120 megabytes of hard disk storage. The vendor may use up to 40 megabytes for their programs and data provided at least a full 80 megabytes of usable storage is available for Colorado Department of Public Health and Environment and user information. The hard disk is to be self-parking (where applicable), shock mounted, and able to operate reliably in the inspection environment. The hard disk must also include a Colorado Department of Public Health and Environment approved method of limiting access to data and programs. The hard disk containing programs and data files shall be designated the "C" drive.

8. I/O Ports

The unit must include sufficient I/O ports of proper configuration to allow the connection of all required options and the capability to add additional I/O boards.

9. Keyboard

The Colorado 94 Analyzer keyboard must be fully interfaced with the microcomputer and have all of the necessary normal, numeric, cursor, control, shift, alternate, and function keys needed to operate a standard IBM PC compatible microcomputer, preferably 101 keys should be provided.

10. Bar Code Scanner

The bar code scanner shall be equivalent to the PDF 1000 "HV" (High Visibility) Scanner from Symbol Technologies. Performance specifications are included in Technical Specification Appendix A. The PDF 1000 "HV" is a scanner capable of reading both 1-D and PDF-417(2-D) bar codes.

11. Hard Disk Expansion

System must include a hard disk interface which will fully support a second internal disk drive of the same type as the original type drive or a functional equivalent approved by the Colorado Department of Public Health and Environment which does not compromise tamper-resistance.

12. Additional Storage

3.5" 1.44 Mb Floppy Disk Drive IBM Optical disk drive, floptical, CD ROM reader etc., these options would be for manufacturer offered look up tables, service information or other options requiring additional storage capability.

13. Communications

Hayes compatible modem at 14,400B, M.N.P. Level 5. Error correction: Microcom networking protocol (M.N.P.) levels 1-4 and V.42 data compression: M.N.P. level 5 and V.32BIS/V.42BIS. Protocol will be provided within the operational software package. Modem communications will be necessary during the inspection process for V.I.N. verification, multiple "I" Test Control, vehicle recall etc., from the Network System Host Computer.

2.15 Required Printers

A. Diagnostic printer:

A 24 pin impact printer shall be supplied which is dedicated to the task of printing designated information on a VEHICLE DIAGNOSTIC FORM, or other repair type information. Continuous, fanfold, preprinted (ghost printed certificates) will be used. The printer shall print information on the certificate using 12 characters per inch and 80 characters per line.

B. Certificate Printer:

The certificate printer is to be a "thermal transfer" technology printer, capable of producing PDF 417, two dimensional bar code and Code 39, one dimensional bar code. As of date, Standard Register produces a model of printer that meets or exceeds all requirements necessary to print upon the required certificate. This model is a PT650 Thermal/Thermal Transfer Printer. Specifications of the certificate printer shall be Standard Register. PT650 or equivalent. With equivalency being defined as successful completion of printing, security, storing and dispensing of the required certificate. Final acceptance of alternative printers lies with written State approval.

Standard Register. PT650 technical specifications are included in the Technical Specification Appendix B.

PHYSICAL SPECIFICATIONS OF CERTIFICATE:

Physical specifications of the certificate, to include print fields, physical design, materials and sizing are to be determined by the Department of Revenue.

C. Certificate Security:

The inspection certificate printer and certificate storage area shall be located in a secured area. Access to the area securing the printer and certificates shall be available only to the licensed inspector at the station. The certificate storage area shall have a redundant security system utilizing both a hardware lock and a software lock which meets Colorado Department of Public Health and Environmnet approval. Certificates will be prevented from being "pulled" through the printer. A form of printer locking must be utilized. The secured area containing certificates and the certificate printer, shall be designed so that the same key can be used to open any access doors which secure any optional storage media. If any of these doors are opened, a microswitch (or equivalent) shall be used which prevents the printing of certificates and records each event with time and date to an entry.dat file.

The purpose of the software lock is to restrict access to the printer with the following exceptions: loading and aligning certificates prior to printing, clearing paper mis-feed or jam problems, etc., and to provide a record of the personnel performing those functions.

The area containing the certificates shall be located so that proper routing is maintained on the certificates as they are fed through the printer.

If tampering occurs, a software lockout algorithm shall be activated which aborts any existing test sequence and prevents further emission testing until the lockout is cleared by an A.I.R.Program official.

There shall be easy access to the vehicle diagnostic report printer so that the inspector can easily replace paper, clear paper jams and change ribbons.

2.16 Clock/Calendar

The analyzer unit shall have a real time clock/calendar which shall make available the current date and time. Date will be in month, day, year format and time will be in 24 hour format. Both time and date shall be updated by the A.I.R. Program system host computer during each transfer of data via the system modem.

The date/time, along with the time the test started and when it ended, is to be included on the test record. The start time is when the inspectors access code is entered and the end time is when the analyzer data is written to the test file.

If the clock/calendar fails or becomes unstable (as referenced to the program host system during modem data transfer), the analyzer unit shall be locked out from I/M testing and a message shall be displayed indicating that service is required.

Resetting of the clock, independent of the host updating, shall require controlled access.

2.17 Lockout Notification

The analyzer shall alert the inspector of any lockout situation by prominently displaying a message on the CRT. Any lock-out condition will be stored to file.

2.18 Vehicle Diagnosis

The analyzer shall be capable of menu selection that will allow the analyzer to be used as an ordinary garage type emissions analyzer for general automotive repair work and diagnostics.

2.19 Software Loading

The inspector shall not have to load the microcomputer's operating or applications software to operate the analyzer. On each POWER ON of the analyzer, the analyzer shall automatically do all microcomputer component self-diagnostics, memory checking, and loading of all necessary operating software without inspector intervention. Upon satisfactory computer component check out, the applications software is to present a menu of available analyzer operations. All offered features are to be menu-driven. For each feature, a context sensitive, on-line help facility is to be provided which can be accessed preferably with a single key stroke.

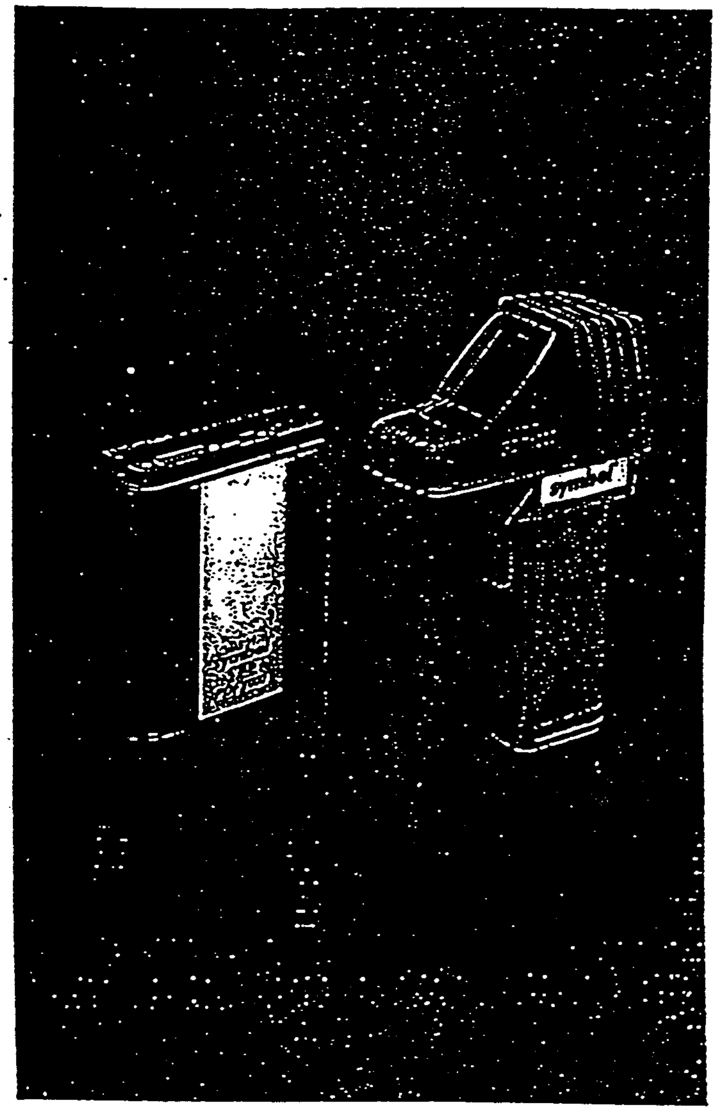
3.0 DISPLAY PROMPTS AND PROGRAMMING CRITERIA REQUIREMENTS

Operational software requirements will be available from the Division upon request.

ATTACHMENT I
TO THE TECHNICAL SPECIFICATION,
APPENDIX A

(TECHNICAL SPECIFICATION)

symbol

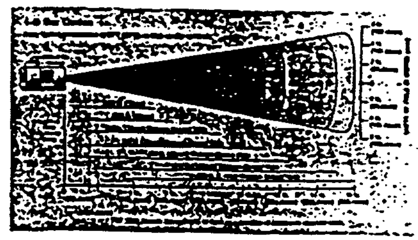


PDF 1000 "PORTABLE DATA FILE"
SCANNING SYSTEM

SPECIFICATIONS

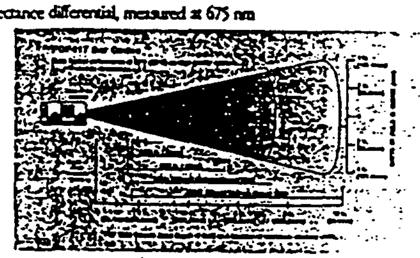
PDF 1000 SCANNER

PERFORMANCE CHARACTERISTICS



- *Type:* Raster scanning, retrocollective
- *Scan Element:* Low mass, single mirror, resonant
- *Light Source:* 675 nm. laser diode
- *Pattern Size:* At 9 in. (22.8 cm) from the nose of the scanner, the pattern is 7 in. (17.8 cm) horizontally and 2.6 in. (6.6 cm) vertically
- *Scan Rate:* 560 scans/sec. 280 Hz ± 10 Hz (horizontal)
- *Frame Rate:* 22 frames/sec. 11 Hz ± 1 Hz (vertical)
- *Optical Resolution:* Can decode a 6.6 mil X-dimension symbol (PDF417); Y-dimension must be 3X
- *Max. Size of PDF417:* 5.9 in. (15 cm) wide x 2.3 in. (5.8 cm) high (928 codewords, at security level 0-8)

PHYSICAL CHARACTERISTICS



- *Pitch Tolerance:* ± 30° ("front and back")
- *Skew:* ±15° from plane parallel to symbol ("side to side")
- *Rotational Tolerance:* ± 3° (assuming 3:1 codeword module aspect ratio)
- *Dead Zone /Optical Throw Print:* ± 2° (1-D symbologies) or ±9° (PDF417) from beam direction
- *Print Contrast Resolution (min.):* 25% (1-D symbologies) or 35% (PDF417) absolute dark/light reflectance differential, measured at 675 nm
- *Ambient Light Immunity:* 8000 ft-candles (86100 Lux) of sunlight
- *Humidity:* 5 to 95% relative humidity (non-condensing)
- *Shock:* Unit functions normally after 4-ft (1.2m) drop to concrete
- *Environmental Sealing:* MIL-STD-810D windblown dust and rain
- *Operating Temperature:* 14° to 104° F (-10° to 40° C)
- *Storage Temperature:* -40° to 140° F (-40° to 60° C)
- *Coil Cable Length:* 6 ft (183 cm)
- *Weight:* 10.4 oz (295 gm) without cable
- *Dimensions:* 7.2 in. (18.2 cm) H x 4.2 in (10.7 cm) L x 1.7 in. (4.3 cm) W
- *Laser Class:* CDRH Class II, IEC 825 Class II

PL 140 DECODER/INTERFACE

- *Decode Capabilities:* 2-D Symbology: PDF417 (up to 928 codewords at security level 0-8). 1-D Symbologies: UPC-A, UPC-E, EAN-8, EAN-13, Code 39, Code 39 Full ASCII, Code 128, Interleaved 2 of 5, Codabar.
- *Memory:* 64K x 32-bit PROM; 32K x 32-bit RAM (128K RAM option); 256 x 16-bits EEPROM for system parameters
- *Humidity:* 5-95% relative humidity (non-condensing)
- *Shock:* 4-ft (1.2 m) drop to concrete
- *Environmental Sealing:* Environmentally sealed against dust and rain (with battery pack attached)
- *Operating Temperature:* 14° to 104° F (-10° to 40° C)
- *Storage Temperature:* -40° to 140° F (-40° to 60° C)
- *Weight:* 11.2 oz (318 gm). With battery pack 27.8 oz (788.13 gm)
- *Dimensions:* 4.0 in. (10.2 cm) high x 4.0 in (10.2 cm) long x 1.4 in. (3.6 cm) wide. (2.8 in [7.1 cm] wide [with battery pack])

PDF 1000 SYSTEM

- *Agency Approvals:* FCC Class A, UL, CSA, VDE
- *Power Requirements:* DC Power: 11 VDC from wall transformer or 6 VDC from Battery Pack. Wall transformer power requirements: 115 VAC @.15A, 220/240 VAC @.075A, 100V @.15A. Battery Pack will support several thousand scans per 8-hour shift. Actual number depends on PDF417 symbol size and mix of 1D bar codes scanned.

symbol®

SYMBOL TECHNOLOGIES, INC.
116 Wilbur Place, Bohemia, New York 11716
TLX: 6711519/FAX: 1-516-563-2831
TEL: 1-516-563-2400/1-800-SCAN 234

SYMBOL TECHNOLOGIES CANADA, INC.
2540 Matheson Boulevard East
Mississauga, Ontario, Canada L4W 4Z2
FAX: 1-416-629-9765/TEL: 1-416-629-7226

For Europe, the Middle East & Africa
SYMBOL TECHNOLOGIES INTERNATIONAL
15 Oaklands Park, Fishponds Road
Wokingham, Berkshire, England RG11 2FD
FAX: 44-734-771996/TEL: 44-734-771399

For Asia
OLYMPUS SYMBOL, INC.
San-Ei Building, 4th Floor
22-2 Nishi-Shinjuku, 1-chome
Shinjuku-ku
Tokyo, 160 Japan
FAX: 81-3-3348-0216/TEL: 81-3-3348-0211

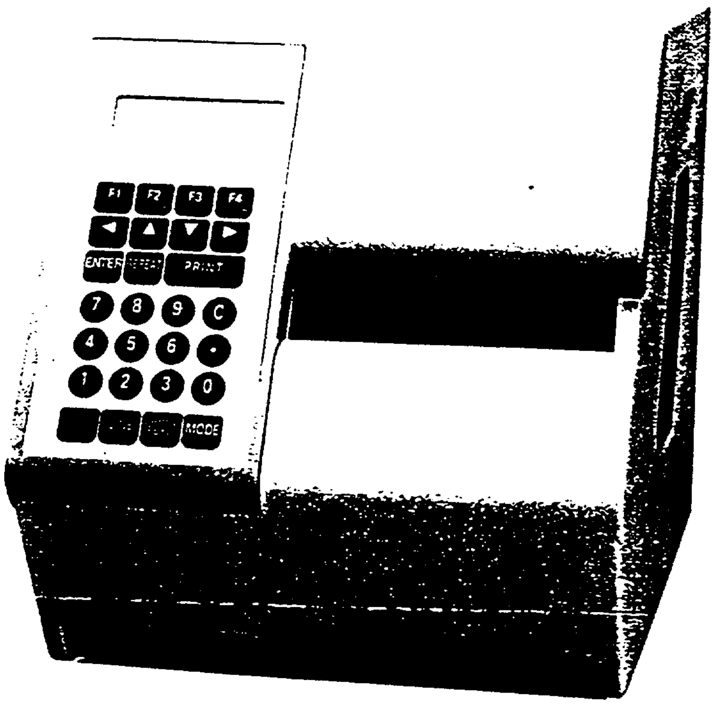
For Latin America & The Caribbean
FAX: 1-516-563-0522/TEL: 1-516-563-4662

SYMBOL TECHNOLOGIES INTERNATIONAL SUBSIDIARIES
Australia (Melbourne)
FAX: 61-3-866-6270/TEL: 61-3-866-6044
Austria (Vienna)
FAX: 43-222-305-39-62/TEL: 43-222-305-37-94/0
France (Asnieres)
FAX: 33-1-40-96-52-52/TEL: 33-1-40-96-52-00
Germany (Darmstadt)
FAX: 49-40-74-427-95/TEL: 49-40-74-490-30
(Duesseldorf)
FAX: 49-211-32-04-70/TEL: 49-211-32-04-52
Italy (Milan)
FAX: 39-2-44-54-505/TEL: 39-2-49-99-056
Spain (Madrid)
FAX: 34-1-320-7412/TEL: 34-1-329-3909
United Kingdom (Wokingham)
FAX: 44-734-773173/TEL: 44-734-771222

ATTACHMENT II
TO THE TECHNICAL SPECIFICATION,
APPENDIX A

Standard Register.

PT650
THERMAL / THERMAL TRANSFER PRINTER



... The Smart Choice

STANDARD FEATURES
- On line / Off line Operation
- Thermal / Thermal Transfer
- Extremely High dot density (203 dots/inch. 8 dots/mm
- Print speed 6 inches plus per second
- Media width 5.25"
- Print width 5.10"
- Large maximum media size 5.25" W X 60" L
- User-selectable bar code ratios
- Internal take-up mechanism
- External rewind mechanism
- Print material. Label and tag stock
- Label presentation
- Print head temperatures software selectable
- Easy - load ribbon
- Alpha-numeric keypad
- LCD Display 2 X 20
- 512K of on board Ram Expandable to 8 MB
- Rotation of text and bar codes 90. 180 and 270 including human readable
- Date and Time Clock
- Label backfeed for cutting and dispensing modes
- Intelligent Formats

PRINT MODES

Three print modes are standard
- Batch - printing one or more labels with or without backing paper
- Rewind - printing a batch of labels and rewinding
- Present Mode - Present sensor stops each label for presentation before delivering the next label

BAR CODES
- Code 39
- Interleave 2 of 5
- Codabar
- Code 128 A. B. and C subsets
- UPC-A and E
- UPC addendum codes 2 and 5 digit
- UPC random weight
- EAN 13 and 8
- Code 93
- Universal shipping contained symbology (with fixed or random weight codes) code 39 variations to produce all industry standards such as LOGMARS. HIBCC. and AIAG
- Bar code modulus ("x" dimensions): 5 mil to 10 mil in picket or ladder orientation
- Bar codes printed with or without human readable interpretation

FONT STYLES
- 12 Scalable Fonts On-Board
- Downloadable font support
- Downloadable graphics
- Inverse text support
- International language support different language character sets
- Inverse image support

MEDIA SPECIFICATIONS
- Media type: Roll-fed. die-cut. continuous or fan-fold labels. tags or tickets
- Material: plain paper thermal transfer or thermal sensitive paper
- Sensing: adjustable transmissive sensor for die cut labels or tags.
- Reflective sensor for use with black marks
- Programmable top of form
- Maximum media width: 5.25"
- Minimum media width: 0.50"
- Maximum media length: 60.0"
- Minimum media length: 0.50"
- Thickness: 0.0023" to 0.012" (including liner)
- Supply roll capacity: 8"(203mm)
- Internal rewind capacity: 6"(152mm)
- External rewind capacity: 8"(203mm)
- Fanfold stock internal and external capabilities

PRINT HEADS
- Standard width: 5.1"(128mm) 8 dot/mm (203 dots/inch. 8 dots/M)
- Optional widths available
- Optional Dot Densities available

PRINT SPEED
- Standard speed: 6"(152mm) plus per second
- Programmable print speeds of 1.5" (38 mm) 3"(72mm) up to 6"(152mm) plus per second

COMMUNICATION INTERFACE
- RS-232C. RS-422. RS-485
- Centronics parallel interface
- Robust XON/XOFF. CTS/DTR handshake
- Programmable 7 or 8 bit length
- Multidrop protocol
- Bidirectional Printer to Host

OPTIONS
- Ribbon Saver
- Cutter mechanism and Tray
- Font Data Cards (up to 1MB)
- Application Cards (up to 1 MB)
- Graphics Display
- Full Alphanumeric keyboard
- Scanner Support
- User Data Support Cards (up to 1MB)
- Twinax & Coax IBM Interfaces

MECHANICAL
- Height: 10"(254mm)
- Width: 11"(279mm)
- Depth: 16"(406mm)
- Weight: 35 lbs. (16 kg)

ELECTRICAL
- Power: 110/220 VAC + or - 10% 50/60 Hz at 2 amps maximum 100 VAC on request
- Built to UL. CSA and TUV-GS safety standards and VDE Class B and FCC Class A emissions standard

ENVIRONMENTAL
- Operating Temperature: 32° F to 100° F (0° to 40° C)
- Storage Temperature: -40° F to 140° F (-40° C to 60° C)
- Humidity: 10% to 90% non-condensing
- Ventilation: Free air movement
- Dust: non-conducting. non-corrosive

ATTACHMENT III
TO
TECHNICAL SPECIFICATION
APPENDIX A

COLORADO
AUTOMOBILE DEALERS
TRANSIENT MODE TEST
ANALYZER SYSTEM

TRANSIENT MODE TEST SYSTEM TECHNICAL AND HARDWARE SPECIFICATIONS

COLORADO AUTOMOBILE DEALERS
TRANSIENT MODE TEST ANALYZER SYSTEM

(I/G 240)

TEST SYSTEM

TECHNICAL AND HARDWARE SPECIFICATIONS

JANUARY 27, 1997

Introduction

This document contains technical specifications for a Colorado Automobile Dealers Transient Mode I/G 240 Test Analyzer System. The technical specifications of the system are based upon the Environmental Protection Agency High-Tech I/M Test Procedures dated June 1996, Emission Standards, Quality Control Requirements and Equipment Specifications: IM240 and Functional Evaporative System Tests technical guidance document EPA-AA-RSPD-IM-96-1, dated June 1996. The technical concept allows for the use of technologies of similar application but of a lower monetary cost. Utilizing lower cost technologies and identifying equipment required to directly address the requirements of the Colorado Enhanced Inspection Program, the system can perform transient loaded mode testing in the Motor Vehicle Dealer Test Facility pursuant to section 42-4-309 (3)(B), C.R.S.

In review of these specifications, sections may indicate that they are *not applicable*. Not applicable indicates that the content of that section does not apply to the Colorado system. Not applicable sections remain within this specification, as they provide insight into the systems total capability with hardware often sharing functionality with another test process. This specification is intended to act as a guide to hardware requirements, provide insight into the application of the hardware, provide testing and quality control requirements and to provide a general overview of the operating system software requirements. Numerical references to methodology or procedures refer to sections so indicated within the code of federal regulations (40 CFR 85.2 July 1996) (EPA).

This attachment III establishes equipment specifications, test procedures and test standards. In order to qualify for the Colorado Automobile Dealers Transient Mode I/G 240 Test Analyzer System must comply with the equipment specifications, must be capable of performing all applicable elements of the test procedure, and must be capable of measuring, calculating, displaying and recording each test standard.

Table of Contents

Test Standards

(a) **Transient Mode Emissions Limits - Regulation No. 11, Part F "Maximum Allowable Emissions Limits"**

EMISSIONS LIMITS

M/Y	CO	HC	NO_x
LDV:			
1982	65	5	8
1983-84	50	5	8
1985	25	5	8
1986-90	25	4	6
1991-94	20	4	6
1995 & newer	20	4	4
LDT 1-2:			
1982-83	107	8	12
1984-85	80	8	12
1986-90	67	6	9
1991 & newer	53	6	9

Emissions limits are subject to periodic revision and as such provisions must be made for ease of adjustments

(b) **Transient Test Score Calculations**

(1) Composite Scores. The composite scores for the test shall be determined by dividing the sum of the mass of each exhaust component obtained in each second of the test by the number of miles driven in the test. The first data point is the sample taken from t=0 to t=1. The composite test value shall be calculated by the equation in (b)(1)(i):

(i) Composite gpm $= \frac{\sum_{sec=0}^{s} \text{grams of emissions}}{\sum_{sec=0}^{s} \text{miles traveled}}$

Where: s = duration of test in seconds for fast pass
= 239 seconds for complete IM240

(2) Second-by-Second Mass Calculations. The mass of each exhaust component shall be calculated to five significant digits for each second of the test using the following equations:

(i) Hydrocarbon mass: $HC_{MASS} = V_{MIX} * DENSITY_{HC} * \frac{HC_{conc}}{1000000}$

(ii) Carbon Monoxide mass: $CO_{MASS} = V_{MIX} * DENSITY_{CO} * \frac{CO_{conc}}{1000000}$

(iii) Oxides of Nitrogen mass: $NO_{XMASS} = V_{MIX} * DENSITY_{NO2} * K_H \frac{NO_{xconc}}{1000000}$

(iv) Carbon Dioxide mass: $CO_{2MASS} = V_{MIX} * DENSITY_{CO2} * \frac{CO_{2conc}}{100}$

(3) Meaning of Terms.

(i) HC_{mass} = Hydrocarbon emissions in grams per second.

(ii) $Density_{HC}$ = Density of hydrocarbons is 16.33 grams per cubic foot assuming an average carbon to hydrogen ratio of 1:1.85 at 68°F and 760 mm Hg pressure.

(iii) HC_{conc} = Average hydrocarbon concentration per second of the dilute exhaust sample measured as described in §85.2226(c)(4), and corrected for background, in ppm carbon equivalent, i.e., equivalent propane * 3.

(A) $HC_{conc} = HC_e - HC_d (1 -)$ Where:

(B) HC_e = Hydrocarbon concentration of the dilute exhaust sample as measured in ppm carbon equivalent.

(C) HC_d = Background hydrocarbon concentration of the dilution air, sampled as described in §85.2221(b)(5), as measured in ppm carbon equivalent.

(D) DF = $\frac{13.4}{CO2_c + (HC_c + CO_c) * 10^{-4}}$ calculated on a second-by-second basis.

(iv) V_{mix} = The CVS flow rate in cubic feet per second corrected to standard temperature and pressure.

(v) CO_{mass} = Carbon monoxide emissions in grams per second.

(vi) $Density_{CO}$ = Density of carbon monoxide is 32.97 grams per cubic foot at 68°F and 760 mm Hg pressure.

(vii) CO_{conc} = Average carbon monoxide concentration per second of the dilute exhaust sample measured as in §85.2226(c)(4), and corrected for background, water vapor, and CO_2 extraction, in ppm.

(A) CO_{conc} = $CO_e - CO_d (1 - \frac{1}{DF})$

(B) CO_e = Carbon monoxide concentration of the dilute exhaust in ppm.

(C) CO_d = Background carbon monoxide concentration of the dilution air, sampled as described in §85.2221(b)(5), in ppm.

(viii) NO_{xmass} = Oxides of nitrogen emissions in grams per second.

(ix) $Density_{NO2}$ = Density of oxides of nitrogen is 54.16 grams per cubic foot assuming they are in the form of nitrogen dioxide at 68°F and 760 mm Hg pressure.

(x) NO_{xconc} = Average concentration of oxides of nitrogen per second of the dilute exhaust sample measured as described in §85.2226(c)(4), and corrected for background in ppm.

(A) NOx_{conc} = $NOx_c - NOx_d (1 - \frac{1}{DF})$

(B) NOx_e = Oxides of nitrogen concentration of the dilute exhaust sample as measure in ppm.

(C) NOx_d = Background oxides of nitrogen concentration of the dilution air, sampled as described in §85.2221(b)(5), measured in ppm.

(xi) K_H = humidity correction factor.

(A) $K_H = \frac{1}{1 - 0.0047 (H - 75)}$

(B) H = Absolute humidity in grains of water per pound of dry air.

(C) $H = \frac{(43.478) R_a * P_d}{P_B - (P_d * \frac{R_a}{100})}$

(D) R_a = Relative humidity of the ambient air, percent.

(E) P_d = Saturated vapor pressure, mm Hg at the ambient dry bulb temperature. If the temperature is above 86° F, then it shall be used in lieu of the higher temperature, until EPA supplies final correction factors.

(F) P_B = Barometric pressure, mm Hg.

(xii) CO_{2mass} = Carbon dioxide emissions in grams per second.

(xiii) $Density_{CO2}$ = Density of carbon dioxide is 51.81 grams per cubic foot at 68°F and 760 mm Hg.

(xiv) CO_{2conc} = Average carbon dioxide concentration per second of the dilute exhaust sample measured as described in §85.2226(c), and corrected for background in percent.

(A) $CO_{2conc} = CO_{2c} - CO_{2d} (1 - \frac{1}{DF})$

(B) CO_{2d} = Background carbon dioxide concentration of the dilution air, sampled as described in §85.2221(b)(5), measured in percent.

(C) (d) **Evaporative System Pressure Test Standards**

(1) Visual Check. The vehicle shall fail the evaporative system visual check if any part of the system is missing, damaged, improperly connected, or disconnected as described in §85.2222(b).

(2) Canister End Pressure Test Standards. **NOT APPLICABLE** The vehicle shall fail the pressure test if the system cannot maintain a pressure above eight inches of water for up to two minutes after being pressurized to 14±0.5 inches of water. The vehicle shall also fail if it does not possess a check valve, as identified in the Look-up Table, and if no pressure drop is detected when the fuel cap is loosened as described in §85.2222(c)(4).

(3) Fuel Inlet Pressure Test. **NOT APPLICABLE**

(i) Pass/Fail Determination. Flow rate, fill pressure, and decay pressure shall be measured at 2 Hz, averaged over 1 second intervals, and curve fitted using a least squares technique. If the volume compensated pressure drop is more than the pressure loss determined from starting and ending pressures in the Pressure Decay Reference Equation in §85.2205(c)(3)(ii), the vehicle shall fail. Otherwise the vehicle shall pass. If not using volume compensation, the vehicle shall fail if the loss in pressure exceeds 6 inches of water.

(ii) Pressure Decay Reference Equation. This equation provides pressure loss values equivalent to a loss of pressure from 14 to 8 inches of water when the starting pressure is other than 14 inches of water.

$$P = 40 * (0.9967 - 2.7 * 10^{-6} * t)^{t}$$

Where:
P = Starting or ending pressure, in inches of water.
t = Time, in seconds.

(iii) Fast-Pass. Fast-pass determinations may be made anytime during the pressure decay between 20 and 120 seconds if the measured pressure exceeds the corresponding Pressure Test Reference Equation cutpoint, from §85.2205 (c)(3)(ii), by 1 inch of water pressure. The cutpoint is determined by adding 1 inch of water to the pressure value at a time t. The pressure at time t corresponds to the pressure at the equivalent "start time" plus the time in seconds between 20 and 120 when the fast pass determination is made. The State may propose and the Division may approve other fast pass algorithms provided they minimize false results.

(iv) Pressure Drop. For vehicles without vapor control valves (burp valves), the clamp(s) shall be removed from the hose(s) and the system shall be monitored for a gradual pressure drop. If no pressure drop is detected, the vehicle shall fail the test. If the Pressure Test Look-up Table identifies the vehicle as possessing a vapor control valve, the system shall not be monitored for a loss of pressure.

(4) Fuel Cap Test. (Part F, Subpart IV of Regulation No. 11)

(i) Pressure Decay Method. If pressure decays by 6 inches of water or more during the 10 second period, the vehicle shall fail the fuel cap integrity test.

(ii) Flow Rate Method. The fuel cap leak rate shall be compared to an orifice with a National Institute of Standards and Technology traceable flow rate which will result in a pass/fail flow rate threshold of 60 cubic centimeters per minute of air at 30 inches of water column. If the leak rate exceeds 60 cubic centimeters per minute at a pressure of 30 inches of water column, the cap shall fail the test.

Transient Mode and Evaporative System Purge Test Procedures

(a) **General Requirements**

(1) Data Collection. The following information shall be determined for the vehicle being tested and used to automatically select the dynamometer inertia and power absorption settings:

(i) Vehicle type: LDGV, LDGT1, LDGT2, and others as needed,
(ii) Chassis model year,
(iii) Make,
(iv) Model,
(v) Number of cylinders, or cubic inch displacement of the engine
(vi) Transmission type.

(2) Ambient Conditions. The ambient temperature, absolute humidity, and barometric pressure shall be recorded continuously during the transient or as a single set of readings up to 4 minutes before the start of the transient driving cycle.

(3) Restart. If shut off, the vehicle shall be restarted as soon as possible before the test and shall be running at least 30 seconds prior to the transient driving cycle.

(b) **Pre-inspection and Preparation**

(1) Accessories. All accessories (air conditioning, heat, defogger, radio, automatic traction control if switchable, etc.) shall be turned off (if necessary, by the inspector).

(2) Leaks. The vehicle shall be inspected for exhaust leaks. Gas measurement of carbon dioxide or other gases shall be acceptable. Vehicles with leaking exhaust systems shall be rejected from testing.

(3) Operating Temperature. The vehicle temperature gauge, if equipped and operating, shall be checked to assess temperature. If the temperature gauge indicates that the engine is not at normal operating temperature, the vehicle shall be inspected and shall get a second-chance emission test if it fails the initial test for any criteria exhaust component. Vehicles in overheated condition shall be rejected from testing.

(4) Tire Condition. Vehicles shall be rejected from testing if the tire cords, bubbles, cuts, or other damage are visible. Vehicles shall be rejected that have space-saver spare tires on the drive axle. Vehicles may be rejected that do not have reasonably sized tires. Vehicle tires shall be visually checked for adequate

pressure level. Drive wheel tires that appear low shall be inflated to approximately 30 psi, or to tire side wall pressure, or manufacturer's recommendation.

(5) Ambient Background. Background concentrations of hydrocarbons, carbon monoxide, oxides of nitrogen, and carbon dioxide (HC, CO, NO_x, and CO_2, respectively) shall be sampled as specified in §85.2226(b)(2)(iv) to determine background concentration of constant volume sampler dilution air. The sample shall be taken for a minimum of 15 seconds within 120 seconds of the start of the transient driving cycle, using the same analyzers used to measure tailpipe emissions except as provided in §85.2221(f)(3). Average readings over the 15 seconds for each gas shall be recorded in the test record. Testing shall be prevented until the average ambient background levels are less than 20 ppm HC, 30 ppm CO, and 2 ppm NOx, or outside ambient air levels (not influenced by station exhaust), which ever are greater.

(6) Sample System Purge. While a system is in operation, the CVS shall continuously purge the CVS hose between tests, and the sample system shall be continuously purged when not taking measurements.

(7) Negative Values. Negative gram per second readings shall be integrated as zero and recorded as such.

(c) Equipment Positioning and Settings

(1) Purge Equipment. **NOT APPLICABLE** If an evaporative system purge test is to be performed:

(i) The evaporative canister shall be checked unless the canister is inaccessible. A missing or obviously damaged canister shall result in failure of the visual evaporative system check.

(ii) The evaporative system shall be visually inspected for the appearance of proper hose routing and connection of hoses, unless the canister is inaccessible. If any evaporative system hose is disconnected, then the vehicle shall fail the visual evaporative system check. All hoses disconnected for the test shall be reconnected after a purge flow test is performed.

(iii) The purge flow measurement equipment shall be connected in series between the evaporative canister and the engine, preferably on the canister end of the hose. For vehicles equipped with a service port for evaporative functional testing, the measurement equipment shall be connected to the port.

(2) Roll Rotation. The vehicle shall be maneuvered onto the dynamometer with the drive wheels positioned on the dynamometer rolls. Prior to test initiation, the rolls shall be rotated until the vehicle laterally stabilizes on the dynamometer.

Drive wheel tires shall be dried if necessary to prevent slippage during the initial acceleration.

(3) Cooling System. Testing shall not begin until the test-cell cooling system is positioned and activated. The cooling system shall be positioned to direct air to the vehicle cooling system, but shall not be directed at the catalytic converter.

(4) Vehicle Restraint. Testing shall not begin until the vehicle is restrained. Any restraint system shall meet the requirements of §85.2226(a)(5)(ii). In addition, the parking brake shall be set for front wheel drive vehicles prior to the start of the test.

(5) Dynamometer Settings. Dynamometer power absorption and inertia weight settings shall be automatically chosen from a Division supplied electronic look-up table which will be referenced based upon the vehicle identification information obtained in (a)(1). Vehicles not listed shall be tested using default power absorption and inertia settings as follows:

DYNAMOMETER DEFAULT SETTINGS

vehicle type	number of cylinders	track road load horsepower	test inertia weight
All	3	12.1	2000
All	4	12.8	2500
All	5	14.5	3000
All	6	14.5	3000
LDGV	8	16.2	3500
LDGT	8	17.7	4000
LDGV	10	16.2	3500
LDGT	10	19.2	4500
LDGV	12	17.7	4000
LDGT	12	20.7	5000

(6) Exhaust Collection System. The exhaust collection system shall be positioned to insure complete capture of the entire exhaust stream from the tailpipe during the transient driving cycle. The system shall meet the requirements of §85.2226(b)(2).

(d) **Vehicle Conditioning**

(1) Second-chance Retest A vehicle shall get a second-chance emission test if it fails the initial test and all criteria exhaust components are at or below 2.0 times the applicable standards.

(2) Program Evaluation. **NOT APPLICABLE** Vehicles being tested for the purpose of program evaluation under §51.353(c) shall receive two full transient emission tests (i.e., a full 240 seconds each). Results from both tests and the test order shall be separately recorded in the test record. Emission scores and results provided to the motorist may be from either test.

(3) Discretionary Preconditioning. Any vehicle may be preconditioned using any of the following methods:

(i) Non-loaded Preconditioning. Increase engine speed to approximately 2500 rpm, for up to 4 minutes, with a tachometer.

(ii) Loaded Preconditioning. Drive the vehicle on the dynamometer at 30 miles per hour for up to 240 seconds at road-load .

(iii) Transient Preconditioning. After maneuver the vehicle onto the dyno, drive a transient cycle consisting of speed, time, acceleration, and relative load as determined by the division.

(e) **Vehicle Emission Test Sequence**

(1) Transient Driving Cycle. The vehicle shall be driven over the following cycle:

Time	Speed	Time	Speed	Time	Speed	Time	Speed	Time	Speed
0	0	48	25.7	96	0	144	24.6	192	54.6
1	0	49	26.1	97	0	145	24.6	193	54.8
2	0	50	26.7	98	3.3	146	25.1	194	55.1
3	0	51	27.5	99	6.6	147	25.6	195	55.5
4	0	52	28.6	100	9.9	148	25.7	196	55.7
5	3	53	29.3	101	13.2	149	25.4	197	56.1
6	5.9	54	29.8	102	16.5	150	24.9	198	56.3
7	8.6	55	30.1	103	19.8	151	25	199	56.6
8	11.5	56	30.4	104	22.2	152	25.4	200	56.7
9	14.3	57	30.7	105	24.3	153	26	201	56.7
10	16.9	58	30.7	106	25.8	154	26	202	56.3
11	17.3	59	30.5	107	26.4	155	25.7	203	56
12	18.1	60	30.4	108	25.7	156	26.1	204	55
13	20.7	61	30.3	109	25.1	157	26.7	205	53.4
14	21.7	62	30.4	110	24.7	158	27.3	206	51.6
15	22.4	63	30.8	111	25.2	159	30.5	207	51.8
16	22.5	64	30.4	112	25.4	160	33.5	208	52.1
17	22.1	65	29.9	113	27.2	161	36.2	209	52.5
18	21.5	66	29.5	114	26.5	162	37.3	210	53
19	20.9	67	29.8	115	24	163	39.3	211	53.5
20	20.4	68	30.3	116	22.7	164	40.5	212	54
21	19.8	69	30.7	117	19.4	165	42.1	213	54.9
22	17	70	30.9	118	17.7	166	43.5	214	55.4
23	14.9	71	31	119	17.2	167	45.1	215	55.6
24	14.9	72	30.9	120	18.1	168	46	216	56
25	15.2	73	30.4	121	18.6	169	46.8	217	56
26	15.5	74	29.8	122	20	170	47.5	218	55.8
27	16	75	29.9	123	20.7	171	47.5	219	55.2
28	17.1	76	30.2	124	21.7	172	47.3	220	54.5
29	19.1	77	30.7	125	22.4	173	47.2	221	53.6
30	21.1	78	31.2	126	22.5	174	47.2	222	52.5
31	22.7	79	31.8	127	22.1	175	47.4	223	51.5
32	22.9	80	32.2	128	21.5	176	47.9	224	50.5
33	22.7	81	32.4	129	20.9	177	48.5	225	48
34	22.6	82	32.2	130	20.4	178	49.1	226	44.5
35	21.3	83	31.7	131	19.8	179	49.5	227	41
36	19	84	28.6	132	17	180	50	228	37.5
37	17.1	85	25.1	133	17.1	181	50.6	229	34
38	15.8	86	21.6	134	15.8	182	51	230	30.5
39	15.8	87	18.1	135	15.8	183	51.5	231	27
40	17.7	88	14.6	136	17.7	184	52.2	232	23.5
41	19.8	89	11.1	137	19.8	185	53.2	233	20
42	21.6	90	7.6	138	21.6	186	54.1	234	16.5
43	23.2	91	4.1	139	22.2	187	54.6	235	13
44	24.2	92	0.6	140	24.5	188	54.9	236	9.5
45	24.6	93	0	141	24.7	189	55	237	6
46	24.9	94	0	142	24.8	190	54.9	238	2.5
47	25	95	0	143	24.7	191	54.6	239	0

(2) Driving Trace. The inspector shall follow an electronic, visual depiction of the time/speed relationship of the transient driving cycle (hereinafter, the trace). The visual depiction of the trace shall be of sufficient magnification and adequate detail to allow accurate tracking by the driver and shall permit the driver to anticipate upcoming speed changes. The trace shall also clearly indicate gear shifts as specified in §85.2221(e)(3).

(3) Shift Schedule. For vehicles with manual transmissions, inspectors shall shift gears according to the following shift schedule:

Shift Sequence *gear*	Speed *miles per hour*	Nominal Cycle Time *seconds*
1 - 2	15	9.3
2 - 3	25	47.0
De-clutch	15	87.9
1 - 2	15	101.6
2 - 3	25	105.5
3 - 2	17	119.0
2 - 3	25	145.8
3 - 4	40	163.6
4 - 5	45	167.0
5 - 6	50	180.0
De-clutch	15	234.5

Gear shifts shall occur at the points in the driving cycle where the specified speeds are obtained. For vehicles with fewer than six forward gears the same schedule shall be followed with shifts above the highest gear disregarded.

(4) Speed Excursion Limits. Speed excursion limits shall apply as follows:

(i) The upper limit is 2 mph higher than the highest point on the trace within 1 second of the given time.

(ii) The lower limit is 2 mph lower than the lowest point on the trace within 1 second of the given time.

(iii) Speed variations greater than the tolerances (such as may occur during gear changes) are acceptable provided they occur for no more than 2 seconds on any occasion.

(iv) Speeds lower than those prescribed during accelerations are acceptable provided the vehicle is operated at maximum available power during such accelerations until the vehicle speed is within the excursion limits.

(v) Exceedances of the limits in §85.2221(i) through §85.2221(iii) shall automatically result in a void test. Tests shall be aborted if the upper excursion limits are exceeded. Tests may be aborted if the lower limits are exceeded.

(5) Speed Variation Limits.

(i) A linear regression of feedback value on reference value shall be performed on each transient driving cycle for each speed using the method of least squares, with the best fit equation having the form: $y = mx + b$, where:

(A) y = The feedback (actual) value of speed;
(B) m = The slope of the regression line;
(C) x = The reference value; and
(D) b = The y-intercept of the regression line.

(ii) The standard error of estimate (SE) of y on x shall be calculated for each regression line. A transient driving cycle lasting the full 240 seconds that exceeds the following criteria shall be void and the test shall be repeated:

(A) SE = 2.0 mph maximum.
(B) m = 0.96 - 1.01.
(C) r^2 = 0.97 minimum.
(D) b = ±2.0 mph.

(iii) A transient driving cycle that ends before the full 240 seconds that exceeds the following criteria shall be void and the test shall be repeated:

(A) SE = (NOT APPLICABLE)
(B) m = (NOT APPLICABLE)
(C) r^2 = (NOT APPLICABLE)
(D) b = (NOT APPLICABLE)

(6) Distance Criteria. The actual distance traveled for the transient driving cycle and the equivalent vehicle speed (i.e., roll speed) shall be measured. If the absolute difference between the measured distance and the theoretical distance for the actual test exceeds 0.05 miles, the test shall be void.

(7) Vehicle Stalls. Vehicle stalls during the test shall result in a void and a new test. More than 3 stalls shall result in test failure.

(8) Dynamometer Controller Check. For each test, the measured horsepower, and inertia if electric simulation is used, shall be integrated from 55 seconds to 81 seconds (divided by 26 seconds), and compared with the theoretical road-load horsepower (for the vehicle selected) integrated over the same portion of the cycle. The same procedure shall be used to integrate the horsepower between 189 seconds to 201 seconds (divided by 12 seconds). The theoretical horsepower shall be calculated based on the observed speed during the integration interval. If the absolute difference between the theoretical horsepower and the measured horsepower exceeds 0.5 hp, the test shall be void. Alternate error checking methods may be used if shown to be equivalent and approved by the division.

(9) Inertia Weight Selection. Operation of the inertia weight selected for the vehicle shall be verified as specified in §85.2226(a)(4)(iii). For systems employing electrical inertia simulation, an algorithm identifying the actual inertia force applied during the transient driving cycle shall be used to determine proper inertia

simulation. For all dynamometers, if the observed inertia is more than 1% different from the required inertia, the test shall be void.

(10) CVS Operation. The CVS operation shall be verified for each test for a CFV-type CVS by measuring either the absolute pressure difference across the venturi or measuring the blower vacuum behind the venturi for minimum levels needed to maintain choke flow for the venturi design. The operation of an SSV-type CVS shall be verified throughout the test by monitoring the difference in pressure between upstream and throat pressure. The minimum values shall be determined from system calibrations. Monitored pressure differences below the minimum values shall void the test.

(11) Fuel Economy. For each test, the health of the overall analysis system shall be evaluated by checking a test vehicle's fuel economy for reasonableness, relative to upper and lower limits, representing the range of fuel economy values normally encountered for the test inertia and horsepower selected. For each inertia selection, the upper fuel economy limit shall be determined using the lowest horsepower setting typically selected for the inertia weight, along with statistical data, test experience, and engineering judgment. A similar process for the lower fuel economy limit shall be used with the highest horsepower setting typically selected for the inertia weight. For test inertia selections where the range of horsepower settings is greater than 5 horsepower, at least two sets of upper and lower fuel economy limits shall be determined and appropriately used for the selected test inertia. Tests with fuel economy results in excess of 1.5 times the upper limit shall result in a void test.

(f) Emission Measurements

(1) Exhaust Measurement. The emission analysis system shall sample and record dilute exhaust HC, CO, CO_2, and NO_X during the transient driving cycle as described in §85.2226(c).

(2) Purge Measurement. **NOT APPLICABLE** The analysis system shall sample and record the purge flow in standard liters per second and total volume of flow in standard liters over the course of the actual driving cycle as described in §85.2227(b).

(3) Integrity Measurement. The analysis system shall measure and record the integrity of the fuel cap as described in §85.2227(c).

Evaporative System Pressure Test Procedures NOT APPLICABLE

(a) General Requirements

(1) The on-vehicle pressure tests described in §85.2222(c) and (d) shall be performed after any tailpipe emission test to be performed on a vehicle. Fuel cap tests described in §85.2222(e) and (f) may be performed before or after the tailpipe emission test.

(2) The pressure test shall be conducted in a manner that minimizes changes in temperature, since pressure measurements are affected by changes in the vapor space temperature.

(3) The Look-up Table identifies which on-vehicle pressure test to perform on a given vehicle. Vehicles receiving the canister end pressure test specified in §85.2222(c) do not need to receive any other pressure tests. Vehicles receiving the fuel inlet pressure test specified in §85.2222(d) should also be given one of the fuel cap pressure tests specified in §§85.2222(e) and (f).

(4) Alternative procedures may be used if they are shown to be equivalent or better to the satisfaction of the Division. Any damage done to the evaporative emission control system during this test shall be repaired.

(b) **Pre-inspection and Preparation**

(1) The evaporative canister(s) shall be visually checked to the degree practical. A missing or obviously damaged canister(s) shall fail the visual evaporative system check.

(2) The evaporative system hoses shall be visually inspected for the appearance of proper routing, connection, and condition, to the degree practical. If any evaporative system hose is misrouted, disconnected, or damaged, the vehicle shall fail the visual evaporative system check.

(3) If the fuel cap is missing, obviously defective or the wrong style cap for the vehicle, the vehicle shall fail the visual evaporative system check.

(c) **Canister-End Pressure Test** NOT APPLICABLE

(1) Equipment Set-up. Test equipment shall be connected to the fuel tank canister hose at the canister end. The fuel cap shall be checked to ensure that it is properly, but not excessively tightened, and shall be tightened if necessary.

(2) Pressure Value. The system shall be pressurized to 14 $\pm$0.5 inches of water without exceeding 26 inches of water system pressure.

(3) Stability. Close off the pressure source, seal the evaporative system and monitor pressure decay for up to two minutes.

(4) Depressurization. Loosen the fuel cap after a maximum of two minutes and monitor for a sudden pressure drop, indicating that the fuel tank was pressurized.

(5) Reconnection. The inspector shall carefully ensure that all items disconnected or loosened in the course of the test are properly reconnected at the conclusion of the test.

(d) **Fuel Inlet Pressure Test** NOT APPLICABLE

(1) Equipment Set-up. The vapor vent line(s) from the fuel tank to the canister(s) shall be clamped off as close to the canister(s) as practical without damaging evaporative system hardware. If the line(s) can not be clamped (for example a rigid line), they shall be removed at the canister(s) and capped or plugged. Dual fuel tanks shall be checked individually if the complete vapor control system can not be accessed by pressurizing from the fill pipe interface of only one fuel tank. A fuel inlet adapter, as specified in §85.2227(c), appropriate to the style of fuel inlet on the vehicle (not the fuel cap on the vehicle) shall be selected based on a software prompt and shall be installed on the vehicle's fuel inlet.

(2) Pressure Value. The fuel tank shall be pressurized to a value at or slightly above the minimum test pressure specified in the Look-up Table.

(3) Stability. Pressure stability shall be maintained for a period of 10 seconds prior to the start of the pressure decay measurement. Pressure shall not increase by more than 0.5 inches of water during the first 20 seconds of the decay measurement. Alternate definitions of stability may be proposed by the state and approved by the Administrator provided they minimize the risk of false results.

(4) Volume Compensation. (Optional) Pressure decay measurements are affected by the vapor volume (fuel tank level) in the fuel tank. Volume-compensated pressure decay measurements will increase test repeatability, and are therefore recommended. Measure the volume-compensated pressure decay for up to 120 seconds after stability is achieved, using the equation in §85.2222(d)(5). This equation is based on normalizing the pressure decay measurements to a vapor volume of 50 liters. The Division may approve other methods of compensation for differences in fuel tank vapor volume.

(5)

$$P = P_0 * K\left(t * \frac{V}{V_s}\right)$$

Where:

P = Pressure, in inches of water at time t, compensated for differences in fuel tank vapor space volume.

P_0 = The stabilized pressure at the start of the decay portion of the pressure test, in inches of water.

k = A constant derived from curve fitting the pressure/time data from the decay portion of the pressure test, using the equation:

$$P = P_0 * k^t$$

t = Time measured from the start of the decay portion of the pressure test, in seconds.

V_s = Reference volume of the fuel vapor space, 50 liters.

V = Volume of the fuel vapor space, in liters, calculated using the following equation:

$$V = \left(P_b * 13.6 + \frac{\text{ÆP}}{2}\right) * \frac{\text{ÆV}}{(\text{ÆP} + \text{ÆP}_L)}$$

Where:

P_b = Barometric pressure, in inches of Hg.

ÆP = Pressure increase during the fill period, in inches of water.

ÆV = The flow meter measured volume of gas which pressurizes the vapor space, in liters at 20 C and 1 atmosphere.

ÆP_L = The loss in pressure due to the presence of a leak during the fill process, in inches of water.

$$\text{ÆP}_L = {}_{t=0}^{\;t} P_0 * k^{\left(\frac{\ln P_t - \ln P_0}{\ln k} - 1\right)} - P_0 * k^{\left(\frac{\ln P_t - \ln P_0}{\ln k}\right)}$$

Where:

_ = Summation of the second-by-second pressure loss during the fill period.

P_0 = The stabilized pressure at the start of the decay portion of the pressure test, in inches of water.

k = A constant derived from curve fitting the pressure/time data from the decay portion of the pressure test, using the equation:

$$P = P_0 * k^t$$

P_t = Pressure values reported in one second intervals during the fill period, in inches of water.

(e) **Fuel Cap Leak Test - Pressure Decay Method**

(1) The fuel cap shall be removed from the fuel inlet and installed on a test rig with a nominal 1 liter head space and be pressurized to 28 ± 1.0 inch of water.

(2) The pressure decay shall be monitored as specified in this Regulation Part F Subpart IV.

(3) The fuel cap shall be replaced on the fuel inlet and tightened appropriately.

(f) **Fuel Cap Leak Test - Flow Rate Method**

(1) The fuel cap shall be removed from the fuel inlet and installed on the flow test device using the adapter appropriate for the fuel cap, as specified in §85.2227(c).

(2) The fuel cap flow rate shall be monitored as specified in this Regulation Part F, Subpart IV.

(3) The fuel cap shall be replaced on the fuel inlet and tightened appropriately.

Colorado Automobile Dealers Transient Mode Test Analyzer System Equipment Specifications

(a) **Dynamometer Specifications**

(1) General Requirements.

(i) The dynamometer structure (e.g., bearings, rollers, pit plates, etc.) shall accommodate all light-duty vehicles and light-duty trucks up to 8500 pounds GVWR.

(ii) Road load horsepower and inertia simulation shall be automatically selected based on the vehicle parameters in the test record.

(iii) Alternative dynamometer specifications or designs may be proposed to the state and approved based upon a determination that, for the purpose of properly conducting an approved Transient Mode inspection, the evidence supporting such deviations will not cause improper vehicle loading .

(2) Power Absorption.

(i) Coefficients. The coefficients A_V, B_V, and C_V, from vehicle track coast down testing, and referenced in the equations in this section are those specified during new car certification, or as specified by a vehicle class designator determined by the Division. Coefficients shall be calculated to a minimum of five (5) significant digits by the equations specified in §85.2226(a)(2)(i)(A) through §85.2226(a)(2)(i)(C). Power fractions determined from track coast-down data shall be calculated to a minimum of two (2) significant digits as specified in §85.2226(a)(2)(i). In the absence of new car certification coefficients information or a vehicle class designator identifying a power fraction, the default power fractions in §85.2226(a)(2)(i)(J) shall be used.

(A) $A_V = * (TRLHP_{@\ 50\ mph})$ hp/mph

(B) $B_V = * (TRLHP_{@\ 50\ mph})$ hp/mph^2

(C) $C_V = * (TRLHP_{@\ 50\ mph})$ hp/mph^3

(D) Where A_VPF, B_VPF, and C_VPF are power fractions (PF), and indicate the fraction of the total power reflected by each coefficient A_V, B_V, and C_V.

(E) $A_VPF + B_VPF + C_VPF = 1$

(F) Derivation of A_VPF, B_VPF, and C_VPF from known track coast-down curves shall be computed as follows:

(1) $A_V PF = \frac{A_V(50)}{\{A_V(50) + B_V(2500) + C_V(125{,}000)\}}$

(2) $B_V PF = \frac{B_V(2500)}{\{A_V(50) + B_V(2500) + C_V(125{,}000)\}}$

(3) $C_V PF = \frac{C_V(125{,}000)}{\{A_V(50) + B_V(2500) + C_V(125{,}000)\}}$

(4) Default values:
$A_V PF = 0.35$
$B_V PF = 0.10$
$C_V PF = 0.55$

(ii) Vehicle Loading. The true vehicle loading used during the transient driving cycle shall follow the equation in §85.2226(a)(2)(iii) between 10 and 60 mph. The dynamometer

controls shall set the dynamometer loading to achieve the coast-down target time (±1 second) with the vehicle on the dynamometer using the vehicle-specific inertia test weights. A conversion equation or table of target time versus horsepower for the dynamometer design shall be used. Target time shall be converted to horsepower by the equation §85.2226(a)(2)(iv) or pre-defined horsepower values may be used.

(iii) $TRLHP_{@\,Obmph} = \{A_V * Obmph\} + \{B_V * Obmph^2\} + \{C_V * Obmph^3\}$

Av, Bv, Cv = Coefficients specified in §85.2226(a)(2)(i) for vehicle track coast down curves.

Obmph = Observed mph

TRLHP = Track Road Load Horsepower, which includes loading contributions from the power absorber, parasitic losses, and tire/roll interface losses.

(iv) Track Road-Load Horsepower $= \frac{\left(\frac{0.5 * ETW}{32.2}\right) * (V_1^2 - V_2^2)}{(550 * ET)}$

ET = Elapsed time for the vehicle on the road to coast down from 55 to 45 mph, and from 22 to 18 mph
ETW = Inertia weight in pounds
V_1 = Initial velocity in feet/second (i.e., velocity at either 55 or 22 mph)
V_2 = Final velocity in feet/second (i.e., velocity at either 45 or 18 mph)

(v) In practice, the true vehicle loading is derived from equations of "force" (i.e., F=MA). In determining vehicle load on a dynamometer, applied loads in units of force tangential to the roll surface are not dependent on the roll diameter used, whereas applied loads in units of torque of horsepower are dependent on the roll diameter. The equation in §85.2226(a)(2)(vi) may be used to convert track road-load horsepower values in §85.2226(a)(2)(iii) to units of force.

(vi) $TRLF_{@\ Obmph} = \{A_f\} + \{B_f * Obmph\} + \{C_f * Obmph^2\}$

TRLF	=	Track Road-Load Force (in units of pounds)	
A_f	=	$375 * A_v$	(A_v in HP/mph units)
B_f	=	$375 * B_v$	(B_v in HP/mph^2 units)
C_f	=	$375 * C_v$	(C_v in HP/mph^3 units)

A_f, B_f, C_f = Equivalent force coefficients to the coefficients specified in §85.2226(a)(2)(i) for vehicle track coast down curves.

(vii) Range and Curve of Power Absorber. The range of power absorber at 50 mph shall be sufficient to cover track road-load horsepower (TRLHP) values between 4 and 35 horsepower. The absorption shall be adjustable across the required horsepower range at 50 mph in 0.1 horsepower increments. The accuracy of the power absorber shall be ±0.25 horsepower or ±2% of point whichever is greater.

(viii) Parasitic Losses (General Requirements). The parasitic losses in each dynamometer system (such as windage, bearing friction, and system drive friction) shall be characterized between 10 and 60 mph upon initial acceptance. There shall be no sudden discontinuities in parasitic losses below 10 mph. Further, when added to the lowest possible loading of the power absorber (dynamometer motoring is considered a negative load), the parasitic losses must be sufficiently small such that proper loading will occur between 10 and 60 mph for a vehicle with a 50 mph track road-load horsepower value of 4 horsepower. The parasitic horsepower losses shall be characterized either digitally in five mph increments and linearly interpolated in-between, or the data at 10 mph increments shall fit the equation in §85.2226(a)(2)(ix) to within 2 percent of point.

(ix) $PLHP = \{A_p * (Obmph)\} + \{(B_p) * (Obmph)^2\} + \{(C_p) * (Obmph)^3\}$

PLHP = Dynamometer parasitic losses.

A_p, B_p, and C_p are curve coefficients necessary to properly characterize the dynamometer parasitic losses for the inertia weight(s) used.

(x) Parasitic Losses (Low Speed Requirements). The coast down time of the dynamometer between 8 and 12 mph shall be greater than or equal to the value calculated by the equation in §85.2226(a)(2)(xi) when the dynamometer is set for a 2000 pound vehicle with a track road-load horsepower of 4 horsepower at 50 mph.

(xi) Low Speed Loading. The following procedure is used to determine if a dynamometer system is correctly loading a vehicle with an ETW of 2000 pounds and a TRLHP of 6.0 horsepower at low speeds. Use "default" coefficients from §85.2226(a)(2)(i)(F)(4). Dynamometer must be warmed up prior to this procedure.

(A) Select vehicle with a driven axle weight between 1200 and 1300 pounds (sandbags or other ballast may be used to achieve this weight). Record vehicles driven axle weight to the nearest pound.

(B) Calculate the actual tire/roll interface losses (ATRL) using the following sub procedure.

(1) Determine PLHP for dynamometer system being tested.

(2) Calculate GTRL using equations from §§85.2226(a)(2)(xiii) and (xv) or (xvi).

(3) Calculate IHP using the following formula:

IHP = TRLHP-PLHP-GTRL

(4) Set dynamometer based on IHP calculated is step C above.

(5) Perform dynamometer coast down with vehicle selected in step 1 correctly positioned on rolls. Record coast down time from 12 mph to 8 mph.

(6) Calculate new TRLHP based on 12 mph to 8 mph coast

(7) Calculate actual tire/roll interface losses (ATRL) using the following equation.

ATRL= TRLHP-PLHP-IHP

(C) Using calculated ATRL determine new IHP using the following formula:

IHP = TRLHP-PLHP-ATRL

(D) Set dynamometer based on IHP calculated is step 3 above.

(E) Perform dynamometer coast down with vehicle selected in step 1 correctly positioned on rolls. Record coast down time from 12 mph to 8 mph.

(F) The maximum, average, and minimum time limits for the on-dynamometer coast-down window at 10 mph shall be calculated by the following equations.

$$DT_{Maximum\ @\ 10\ mph} = \frac{\left(\frac{0.5 * ETW}{32.17405}\right) * (V_{12}^{2} - V_{8}^{2})}{550 * (TRLHP_{@10mph})}$$

$$DT_{Average\ @\ 10\ mph} = \frac{\left(\frac{0.5 * ETW}{32.17405}\right) * (V_{12}^{2} - V_{8}^{2})}{550 * (TRLHP_{@10mph} - 0.088\ HP)}$$

$$DT_{Minimum\ @\ 10\ mph} = \frac{\left(\frac{0.5 * ETW}{32.17405}\right) * (V_{12}^{2} - V_{8}^{2})}{550 * (TRLHP_{@10mph} + 0.088\ HP)}$$

(xii) <u>Tire/Roll Interface Losses</u>. Generic tire/roll interface losses shall be determined for each dynamometer design used, and applied to obtain proper vehicle loading. A means to select or determine the appropriate generic tire/roll interface loss for each test vehicle shall be employed. Dynamometer design parameters include roll diameter, roll spacing, and roll surface finish. Generic tire/roll interface losses may be determined by the acceptance procedures in §85.2234(b)(4). Alternatively, generic values determined by the division, or by a procedure accepted by the division, may be used. The equation in §85.2226(a)(2)(xiii) may be used to quantify tire/roll interface losses. Coefficients for equation in §85.2226(a)(2)(xiii) shall be calculated to a minimum of five (5) significant digits by the equations specified in §85.2226(a)(2)(xiii)(A) through §85.2226(a)(2)(xiii)(I). Tire loss power fractions determined from track coast-down data shall be calculated to a minimum of two (2) significant digits as specified in §85.2226(a)(2)(xiii)(J). In the absence of new car certification information or a vehicle class designator identifying a tire loss power fraction, the default tire loss power fractions indicated equations §85.2226(a)(2)(xiii)(E) through §85.2226(a)(2)(xiii)(I) shall be used as specified in §85.2226(a)(2)(xiii)(J).

(xiii) $GTRL_{@\ Obmph} = \{A_t * (Obmph)\} + \{B_t * (Obmph)^2\} + \{C_t * (Obmph)^3\}$

$GTRL_{@\ Obmph}$ = Generic Tire/Roll Interface losses at the observed mph

Where: A_t, B_t, and C_t are curve coefficients necessary to properly characterize the tire/roll interface losses.

(A) A_t = * $(GTRL_{@\ 50\ mph})$ hp/mph

(B) B_t = * $(GTRL_{@\ 50\ mph})$ hp/mph2

(C) C_t = * ($GTRL_{@ 50 mph}$) hp/mph^3

(D) A_{t8} = * ($GTRL_{@ 50 mph}$) hp/mph

(E) B_{t8} = * ($GTRL_{@ 50 mph}$) hp/mph2

(F) C_{t8} = * ($GTRL_{@ 50 mph}$) hp/mph^3

(G) A_{t20} = * ($GTRL_{@ 50 mph}$) hp/mph

(H) B_{t20} = * ($GTRL_{@ 50 mph}$) hp/mph2

(I) C_{t20} = * ($GTRL_{@ 50 mph}$) hp/mph^3

(J) Where:

(1) A_t, B_t, and C_t are curve coefficients necessary to properly characterize the tire/roll interface losses.

(2) A_{t8}, B_{t8}, and C_{t8} are curve coefficients when using twin 8.625 inch diameter rolls.

(3) A_{t20}, B_{t20}, and C_{t20} are curve coefficients when using twin 20.0 inch diameter rolls.

(4) A_tPF, B_tPF, and C_tPF indicate the fraction of the total tire loss power fraction reflected by each coefficient A_t, B_t, and C_t.

(5) $A_tPF + B_tPF + C_tPF = 1$

(6) Derivation of A_tPF, B_tPF, and C_tPF from known track or dynamometer data shall be computed as follows:

$$A_tPF = \frac{A_t\,(50)}{\{A_t\,(50) + B_t\,(2500) + C_t\,(125{,}000)\}}$$

$$B_tPF = \frac{B_t\,(2500)}{\{A_t\,(50) + B_t\,(2500) + C_t\,(125{,}000)\}}$$

$$C_tPF = \frac{C_t\,(125{,}000)}{\{A_t\,(50) + B_t\,(2500) + C_t\,(125{,}000)\}}$$

(xiv) In the absence of new car certification $GTRL_{@ 50 mph}$ or a vehicle class designator, the $GTRL_{@ 50 mph}$ shall be calculated

(A) by the equation in §85.2226(a)(2)(xv) when using twin 8.625 inch diameter rolls

(B) by the equation in §85.2226(a)(2)(xvi) when using twin 20.0 inch diameter rolls

(xv) For 8.625" dynamometers:

$$GTRL_{@ 50 mph} = (-0.378193) + \{(0.0033207) * (DAXWT)\}$$

Where: $DAXWT$ = Axle weight on the drive tires
$GTRL_{@\,50\,mph}$ = Losses for 8.625 inch diameter roll

(xvi) For 20" dynamometers:

$$GTRL_{@\,50\,mph} = (0.241645) + \{(0.0020844) * (DAXWT)\}$$

Where: $DAXWT$ = Axle weight on the drive tires
$GTRL_{@\,50\,mph}$ = Losses for 20.0 inch diameter roll

(xvii) Indicated Horsepower. The power absorption for each test shall be selected at 50 mph. The indicated power absorption (IHP) at 50 mph after accounting for parasitic and generic tire losses shall be determined by the equation in §85.2226(a)(2)(xv).

(xviii) $IHP_{@\,50\,mph} = TRLHP_{@\,50\,mph} - PLHP_{@\,50\,mph} - GTRL_{@\,50\,mph}$

(xix) In systems where the power absorption is actively controlled, the indicated horsepower at each speed between 0 and 60 mph shall conform to the equation in §85.2226(a)(2)(xvii). Approximations for a smooth curve with no discontinuities may be used between 0 and 10 mph.

(xx) $IHP_{@\,Obmph} = TRLHP_{@\,Obmph} - PLHP_{@\,Obmph} - GTRL_{@\,Obmph}$

(3) Rolls.

(i) Size and Type. The dynamometer shall be equipped with twin rolls. The rolls shall be coupled side to side. In addition, the front and rear rolls shall be coupled. The dynamometer roll diameter shall be between 8.5 and 21.0 inches. The spacing between the roll centers shall comply with the equation in §85.2226(a)(3)(ii) to within +0.5 inches and -0.25 inches. The parasitic and generic tire/roll interface losses for the specific roll diameter, spacing, and surface finish used shall be determined as indicated in §85.2226(a)(2)(viii), (a)(2)(ix), and §85.2226(a)(2)(xii) as necessary to properly load vehicles as defined in §85.2226(a)(2)(ii) and §85.2226(a)(2)(iii). The dynamometer rolls shall accommodate an inside track width of 30 inches and an outside track width of at least 100 inches.

(ii) Roll Spacing = (24.375 + D) * SIN 31.5153_

D = dynamometer roll diameter.

Roll spacing and dynamometer roll diameter are expressed in inches.

(iii) Design. The roll size, surface finish, and hardness shall be such that tire slippage on the first acceleration of the transient driving cycle is minimized under all weather conditions; that the specified accuracy of the distance measurement is maintained; and that tire wear and noise are minimized.

(4) Inertia.

(i) Mechanical Inertia Simulation. **NOT APPLICABLE** The dynamometer shall be equipped with mechanical flywheels providing test inertia weights between at least 2000 to 5500 pounds, in increments of no greater than 500 pounds. The tolerance on the base inertia weight and the flywheels shall be within 1% of the specified test weights. The proper inertia weight for any test vehicle shall be selectable.

(ii) Electric Inertia Simulation. Electric inertia simulation, or a combination of electric and mechanical simulation may be used in lieu of mechanical flywheels, provided that the performance of the electrically simulated inertia complies with the following specifications. Exceptions to these specifications may be allowed upon a determination by the Division that such exceptions would not significantly increase vehicle loading or emissions for the purpose of properly conducting an approved IG 240 test.

(A) System Response. The torque response to a step change shall be at least 90% of the requested change within 100 milliseconds after a step change is commanded by the dynamometer control system, and shall be within 2 percent of the commanded torque by 300 milliseconds after the command is issued. Any overshoot of the commanded torque value shall not exceed 25 percent of the torque value.

(B) Simulation Error. An inertia simulation error (ISE) shall be continuously calculated any time the actual dynamometer speed is above 10 MPH and below 60 MPH. The ISE shall be calculated by the equation in §85.2226(a)(4)(ii)(C), and shall not exceed 1 percent of the inertia weight selected (IW_s) for the vehicle under test.

(C) $ISE = (IW_s - I_t) / (IW_s) * 100$

(D) $I_t = I_m +$

Where:

I_t = Total inertia being simulated by the dynamometer (kg)

I_t (lb force) = It (kg) * 2.2046

I_m = Base (mechanical inertia of the dynamometer (kg)

V = Measured roll speed (m/s)

F_m = Force measured by the load cell (translated to the roll surface) (N)

F_{rl} = Road load force (N) required by IHP at the measured roll speed (V)

t = Time (sec)

(iii) Inertia Weight Selection. **NOT APPLICABLE** For dynamometer systems employing mechanical inertia flywheels, the test system shall be equipped with a method, independent from the flywheel selection system, that identifies which inertia weight flywheels are actually rotating during the transient driving cycle.

(5) Other Requirements.

(i) Test Distance and Vehicle Speed. The total number of dynamometer roll revolutions shall be used to calculate the distance traveled. Pulse counters may be used to calculate the distance directly if there are at least 16 pulses per revolution. The measurement of the actual roll distance for the composite and each phase of the transient driving cycle shall be accurate to within ±0.01 mile. The measurement of the roll speed shall be accurate to within ±0.1 mph. Roll speed measurement systems shall be capable of accurately measuring a 3.3 mph per second acceleration rate over a one second period with a starting speed of 10 mph.

(ii) Vehicle Restraint. The vehicle shall be restrained during the transient driving cycle. The restraint system shall be designed to minimize vertical and horizontal force on the drive wheels such that emission levels are not significantly affected.

(iii) Vehicle Cooling. The test system shall provide for a method to prevent overheating of the vehicle. The cooling method shall direct air to the cooling system of the test vehicle. The cooling system capacity shall be 5400 ±300 SCFM within 12 inches (30.5 cm) of the intake to the vehicle's cooling system. The cooling system design shall avoid improper cooling of the catalytic convertor.

(iv) Four-Wheel Drive. **OPTIONAL** If used, four-wheel drive dynamometers shall insure the application of correct vehicle loading as defined in §85.2226(a)(2) and shall not damage the four wheel drive system of the vehicle. Front and rear wheel rolls shall maintain speed synchronization within 0.2 mph.

(v) Augmented Braking. **NOT APPLICABLE** Fully automatic augmented braking shall be used from seconds 85 through 95 and after second 223 of the driving cycle. Fully automatic augmented braking may be used in other deceleration periods of the driving cycle with the approval of the Division. During the periods of augmented braking the operator shall be made aware that augmented braking is occurring and shall be trained not to use the vehicle accelerator during these periods. It shall be automatically interlocked such that it can be actuated only while the vehicle brakes are applied. Simultaneous engine acceleration is systematically prevented through periodic quality assurance.

(b) Constant Volume Sampler

(1) General Design Requirements.

(i) Venturi Type. A constant volume sampling (CVS) system of the critical flow venturi (CFV), sub-sonic venturi (SSV), or square edged orifice (SEO) type shall be used to collect vehicle exhaust samples. The CVS system and components shall generally conform to the specifications in §86.109-90.

(ii) CVS Flow Size. The CVS system shall be sized in a manner that prevents condensation in the dilute sample over the range of ambient conditions to be encountered during testing. A minimum 325 SCFM CVS system and heated lines or sample conditioning system (dryer) may be used to eliminate condensation and to increase measured concentrations for better resolution. Should the heated sample lines be used, the sample line and components (e.g., filters, etc.) shall be heated to a minimum of 120° F and a maximum of 250°F, which shall be monitored during the transient driving cycle.

(iii) CVS Compressor. The CVS compressor flow capacity shall be sufficient to maintain proper flow in the main CVS venturi with an adequate margin. For CFV CVSs the margin shall be sufficient to maintain choke flow. The capacity of the blower relative to the CFV flow capacity shall not be so large as to create a limited surge margin.

(iv) Materials. All materials in contact with exhaust gas shall be unaffected by and shall not affect the sample (i.e., the materials shall not react with the sample, and neither shall they taint the sample as a result of out gassing). Acceptable materials include stainless steel, Teflon, silicon rubber, and Tedlar.

(v) Alternative Approaches. Alternative CVS specifications, materials, or designs may be allowed upon a determination by the Division, that for the purpose of properly conducting an approved short test, the evidence supporting such deviations will not significantly affect the proper measurement of emissions.

(2) Sample System.

(i) Sample Probe. The sample probe within the CVS shall be designed such that a continuous and adequate volume of sample is collected for analysis. The system shall have a method for determining if the sample collection system has deteriorated or malfunctioned such that an adequate sample is not being collected, or that the response time has deteriorated such that the time correlation for each emission constituent is no longer valid.

(ii) CVS Mixing Tee.

(A) Design and Effect. The mixing tee for diluting the vehicle exhaust with ambient air shall be at the vehicle tailpipe exit as in §86.109-90(a)(2)(iv). The dilution mixing tee shall be capable of collecting exhaust from all light-duty vehicle and light-duty truck exhaust systems. The design used shall not cause static pressure in the tailpipe to change such that the emission levels are significantly affected. A change of ±1.0 inch of water, or less, shall be acceptable.

(B) Locating Device. The mixing tee shall have a device for positively locating the tee relative to the tailpipe with respect to distance from the tailpipe, and with respect to positioning the exhaust stream from the tailpipe(s) in the center of the mixing tee flow area. The locating device, or the size of the entrance to the tee shall be such that if a vehicle moves laterally from one extreme position on the dynamometer to the other extreme, that mixing tee will collect all of the exhaust sample.

(iii) Dual Exhaust. For dual exhaust systems, the design used shall insure that each leg of the sample collection system maintains equal flow. Equal flow will be assumed if the design of the "Tee" intersection for the dual CVS hoses is a "Y" that minimizes the flow loss from each leg of the "Y," if each leg of the dual exhaust collection system is approximately equal in length (± 1 foot), and if the dilution area at the end of each leg is approximately equal. In addition, the CVS flow capacity shall be such that the entrance flow velocity for each leg of the dual exhaust system is sufficient to entrain all of the vehicle's exhaust from each tailpipe.

(iv) Background Sample. The mixing tee shall be used to collect the background sample. The position of the mixing tee for taking the background sample shall be within 12 lateral and 12 longitudinal feet of the position during the transient driving cycle, and approximately 4 vertical feet from the floor.

(v) Integrated Sample. A continuous dilute sample shall be provided for integration by the analytical instruments in a manner similar to the method for collecting bag samples as described in §86.109.

(c) **Analytical Instruments**

(1) General Requirements.

(i) The emission analysis system shall automatically sample, integrate, and record the specified emission values for HC, CO, CO2, and NOx. Performance of the analytical instruments with respect to accuracy and precision, drift, interferences, noise, etc. shall be similar to instruments used for testing under §86 Subparts B, D, and N. Analytical instruments shall perform in this manner in the full range of operating conditions in the system environment.

(ii) Alternative analytic equipment specifications, materials, designs, or detection methods may be allowed upon a determination by the Division, that for the purpose of properly conducting an approved short test, the evidence supporting such deviations will not significantly affect the proper measurement of emissions.

(2) Detection Methods and Instrument Ranges.

(i) Total Hydrocarbon Analysis. Total hydrocarbon analysis shall be determined by a flame ionization detector. If a 325 SCFM CVS is used, the analyzer calibration curve shall cover at least the range of 0 ppmC to 4,000 ppmC. Use of a different CVS flow capacity shall require an adjustment to these ranges. Appropriate documentation supporting any adjustment in ranges shall be available. Such documentation shall also address the ability of any altered ranges to accurately measure all cutpoints, including cutpoints for vehicles older than those specified in §85.2205(a), that may be used in the specific I/M program for which the altered ranges are proposed to be used. The calibration curve must comply with the quality control specifications in §85.2234(d).

(ii) Carbon Monoxide Analysis. CO analysis shall be determined using a non-dispersive infrared analyzer. If a 325 SCFM CVS is used, CO analysis shall cover at least the range of 0 ppm to 20,000 ppm (2%). ppm. Use of a different CVS flow capacity shall require an adjustment to these ranges. Appropriate documentation supporting any adjustment in ranges shall be available. Such documentation shall also address the ability of any altered ranges to accurately measure all cutpoints, including cutpoints for vehicles older than those specified in §85.2205(a), that may be used in the specific I/M program for which the altered ranges are proposed to be used. The calibration curve must comply with the quality control specifications in §85.2234(d).

(iii) Carbon Dioxide Analysis. CO_2 analysis shall be determined using an NDIR analyzer. If a 325 SCFM CVS is used, CO_2 analysis shall cover at least the range of 0 ppm to 80,000 ppm (8%). Use of a different CVS flow capacity shall require an adjustment to these ranges. Appropriate documentation supporting any adjustment in ranges shall be available. Such documentation shall also address the ability of any altered ranges to accurately measure all cutpoints, including cutpoints for vehicles older than those specified in §85.2205(a), that may be used in the specific I/M program for which the altered ranges are proposed to be used. The calibration curve must comply with the quality control specifications in §85.2234(d).

(iv) Oxides of Nitrogen Analysis. NOx analysis shall be determined using chemiluminescence. The NOx measurement shall be the sum of nitrogen oxide and nitrogen dioxide. If a 325 SCFM CVS is used, the NOx analysis shall cover at least the range of 0 ppm to 1000 ppm. Use of a different CVS flow capacity shall require an adjustment to these ranges. Appropriate documentation supporting any adjustment in ranges shall be available. Such documentation shall also address the ability of any altered ranges to accurately measure all cutpoints, including cutpoints for vehicles older than those specified in this Regulation Part F, that may be used for which the altered ranges are proposed to be used. The calibration curve must comply with the quality control specifications in §85.2234(d).

(3) System Response Requirements. The governing requirement for system response is the ability of the integration system to measure vehicle emissions to within ±5% of that measured from a bag sample simultaneously collected over the same integration period, on both clean and dirty vehicles. Historically, continuously integrated emission analyzers have been required to have a response time of 1.5 seconds or less to 90% of a step change, where a step change was 60% of full scale or better. System response times between a step change at the probe and reading 90% of the change have generally been less than 4 - 10 seconds. Systems proposed that exceed these historical values shall provide an engineering explanation as to why the slower system response of the integrated system will compare to the bag reading within the specified 5%.

(4) Integration Requirements.

(i) The analyzer voltage responses, CVS pressure(s), CVS temperature(s), dynamometer speed, and dynamometer power shall be sampled at a frequency of no less than 5 Hertz, and the voltage levels shall be averaged over 1 second intervals.

(ii) The system shall properly time correlate each analyzer signal , CVS signals and dynamometersignals to the driving trace (test time). The driving trace update rate from the computer shall be at a rate to produce a smooth transition from one data point to another.

(iii) The one-second average analyzer voltage levels shall be converted to concentrations by the analyzer calibration curves. Corrected concentrations for each gas shall be derived by subtracting the pre-test background concentrations from the measured concentrations, according to the method in §85.2205(b). The corrected concentrations shall be converted to grams for each second using the equations specified in §85.2205(b) to combine the concentrations with the CVS flow over the same interval. The grams of emissions per test phase shall be determined using the equations in §85.2205(b).

(iv) When multiple analyzers are used for any constituent, the integration system shall simultaneously integrate both analyzers. The integrated values for the lowest analyzer in range shall be used for each second.

(v) For all constituents, the background concentration levels from the lowest range analyzer shall be used, including the case where multiple analyzers may have been used.

(5) Analytical System Design.

(i) Materials. All materials in contact with exhaust gas prior to and throughout the measurement portion of the system shall be unaffected by and shall not affect the sample (i.e., the materials shall not react with the sample, and neither shall they taint the sample as a result of out gassing). Acceptable materials include stainless steel, Teflon, silicon rubber, and Tedlar.

(ii) Bag Ports. All analysis systems shall have provisions for reading a sample bag. A portable pump for sampling such bags is permitted.

(iii) System Filters. The sample system shall have an easily replaceable filter element to prevent particulate matter from reducing the reliability of the analytical system. The filter element shall provide for reliable sealing after filter element changes. If the sample line is heated, the filter system shall also be heated.

(iv) Availability of Intermediate Calculation Variables. Upon request prior to a test, all intermediate calculation variables shall be available to be downloaded to electronic files or hard copy. These variables shall include those that calculate the vehicle emission test results, perform emission analyzer and dynamometer function checks, and perform quality assurance and quality control measurements.

(d) Colorado Automobile Dealers Transient Mode Test Analyzer System Specific Hardware

General Design Requirements.

(i) Computer System. Minimum CPU system to include; 90MHZ Pentium processor, Memory 16MB, Secondary Cache 256 KB, Video Type SVGA, Video Card 2 MB memory, 15" Color Monitor (drivers aid), Diskette drive A 1.44 MB, Hard-disk drive C 1.6 GB, Parallel Port (1), Serial Port (1), Mouse Port (1), 104 Key Keyboard, Expansion Slots (4). Port configurations noted may not reflect the necessary number or type to support subsystem requirements or options.

(ii) Modem. Minimum requirement. Hayes compatible able to operate at 14.400B M.N.P. level 5. Error correction, Microcom networking protocol

(M.N.P.) levels 1-4 with V.42 data compression. M.N.P. level 5 - V.32BIS/V.42BIS.

(iii) Printer. Vehicle Inspection Report. 24 pin impact printer operating at 12 characters per inch and 80 characters per line.

(iv) Printer.. Diagnostic Report. (customer option) 24 pin impact printer operating at 12 characters per inch and 80 characters per line.

(v) Printer. Certificate/Sticker. A Standard Register PT-640, thermal transfer printer.

(vi) Barcode Scanner. Symbol Technologies PDF 1000 HV or equivalent.

(1) Fuel cap Tester. An internal or external unit capable of performing either the pressure decay method or flow rate method of fuel cap testing as defined in Evaporative System Test Procedures, sections (e) and (f).

(2) System Security. Access to the analytical system, computer system, official state documents shall be prevented by locked enclosure and monitored by micro switches or other similar means to assure that unauthorized access is denied. Detection of unauthorized access shall result in automatic inspection system lock out.

(3) Manufacturer Options installed to operate independent of an official inspection processes may be utilized and configured into the hardware as necessary. An example would be a CD-ROM for vehicle diagnostics or software supported programs.

Evaporative System Inspection Equipment

(a) General Requirements

(1) Equipment Design. Automated and computerized test systems shall be used for the evaporative system tests. Pass/fail decisions shall be made automatically. The systems shall be tamper resistant and designed to avoid damage to the vehicle during installation, testing, and removal.

(2) Alternative Systems. Alternative purge or pressure test equipment, specifications, materials, or designs, may be proposed and approved upon a determination by the division that, for the purpose of properly conducting an approved Transient Mode test, the evidence supporting such deviations will not appreciably or adversely affect the proper determination of system integrity, the proper measurement of purge, or the proper operation of the vehicle.

(b) Evaporative Purge System NOT APPLICABLE

(1) General Requirements. The evaporative purge analysis system shall measure the instantaneous purge flow in standard liters/minute, and shall compute the total volume of the flow in standard liters over the transient driving cycle.

(2) Specifications. The purge flow measuring system shall comply with the following requirements.

(i) Flow Capacity. A minimum of 50 liters per minute.

(ii) Pressure Drop. Maximum of 16 inches of water at 50 liters per minute for the complete system including hoses necessary to connect the system to the vehicle.

(iii) Totaled Flow. 0 to 100 liters of volume

(iv) Response Time. 410 milliseconds maximum to 90% of a step change between approximately 2 and 10 liters per minute measured with air.

(v) Accuracy.

(A) ±2.0 liters per minute between 10 and 50 liters per minute (rate)

(B) ±0.15 liters per minute between 0 and 10 liters per minute (rate)

(C) ±4% of 50 standard liters total flow volume between 10 and 50 liters total flow volume over one minute.

(D) ±1.5% of 10 standard liters between 0 and 10 liters total volume flow over one minute.

(vi) Noise. The maximum noise shall be less than 0.001 liters per second

(vii) Calibration Gas. Air

(3) Automatic Operation. Vehicle purge flow shall be monitored with a computerized system at a minimum sample rate of 1 Hz, shall automatically capture average (if sampled faster than 1 Hz) second-by-second readings, and shall automatically derive a pass/fail decision. In determining the total volume of flow, the monitoring system shall not count signal noise as flow volume. The test sequence shall be automatically initiated when the transient driving cycle test is initiated.

(4) Adaptability. The purge flow system shall have sufficient adapters to connect in a leak-tight manner with the variety of evaporative systems and hose deterioration conditions in the vehicle fleet. The purge measurement system shall not substantially interfere with purge flow.

(c) Evaporative System Pressure Test Equipment ITEMS 1-4

NOT APPLICABLE

(1) General Requirements.

(i) Pressure Gas. Nitrogen (N2), or equivalent non-toxic, non-greenhouse, inert gas, shall be used for pressurizing the evaporative system.

(ii) Automatic Operation. The process for filling the evaporative system, monitoring compliance, recording data, and making a pass/fail decision shall be automatic. After the determination that the evaporative system has been filled to the specific pressure level, and upon initiation of the test, the pressure level in the evaporative system shall be recorded at a frequency of no less than 1 Hertz until the conclusion of the test.

(iii) Test Abort. The system shall be equipped with an abort system that positively shuts off and relieves pressure. The abort system shall be capable of being activated quickly and conveniently by the inspector should the need arise.

(2) Adapters and Clamps.

(i) Canister Hose Adapters. The system shall have sufficient adapters to connect in a leak-tight manner with the variety of evaporative systems and hose deterioration conditions in the vehicle fleet.

(ii) Fuel Inlet Adapters. Fuel inlet adapters that fit on the vehicles fuel inlet in a manner similar to the fuel cap and designed to admit a pressurized source of gas into the fuel tank shall be used for the fuel inlet pressure test specified in 85.222(d). Inlet specific adapters shall be available for at least 95 percent of the fuel inlets that are used on U.S. light duty vehicles and light duty trucks for the model years Specified in Part F of this Regulation. Varying internal volumes of the adapter assemblies shall not affect the accuracy of the test results. Adapters shall be made available within two years of the introduction of new model year vehicles.

(iii) Hose Clamp. The hose clamp used for the fuel inlet pressure test shall be designed to apply only enough pressure to close the hose without damaging it. The nose of the clamp shall be smooth-surfaced or otherwise designed to avoid abrasion of the vehicle hose.

(3) Pressure Gauge. The device for measuring pressure in the vehicle's evaporative system shall have a minimum range of 0 to 50 inches of water and an accuracy of +-0.3 inches of water (2%of 15) or better.

(4) Flow Meter. A flow meter with a range of at least 0 to 10 liters per minute and +-5% accuracy shall be used for the measurement of flow.

(5) Fuel Cap Tester. The tester shall provide a visual or digital signal that the required air supply pressure is within the acceptable range and the flow comparison test is ready to be conducted. The tester shall incorporate an upstream maintainable filter. If the tester is battery powered, it must be equipped

with an automatic shutoff and a low-battery indicator. A NIST traceable reference passing fuel cap of nominal 52-56 cubic centimeters per minute, and a NIST traceable reference failing fuel cap of nominal 64-68 cubic centimeters per minute shall be supplied with the tester for daily test verification. Leak rate measurements shall be accurate to ±3 cubic centimeters per minute.

(6) Flow Standard. The flow standard shall be a square edged circular orifice with a NIST traceable flow rate which in combination with the comparison circuitry will produce a pass/fail threshold of 60 cubic centimeters at 30 inches of water column. Transducers used in the comparison circuitry shall have accuracy traceable to NIST. The supply pressure may be obtained using room air and any convenient low pressure source. The tester shall control the supply pressure and prevent over pressurization.

Quality Control Requirements and Acceptance Testing Procedures

(a) General Requirements

(1) Minimums. The frequency and standards for quality control specified here are minimum requirements, unless modified as specified in §85.2234(2). Greater frequency or tighter standards may be used as determined by the Division.

(2) Statistical Process Control. Reducing the frequency of the quality control checks, modifying the procedure or specifications, or eliminating the quality control checks altogether may be allowed if the Division determines, for the purpose of properly conducting an approved short test, that sufficient Statistical Process Control (SPC) data exist to make a determination, that the SPC data support such action, and that taking such action will not significantly reduce the quality of the emission measurements. Should emission measurement performance or quality deteriorate as a result of allowing such actions, the approval shall be suspended, and the frequencies, procedures, specifications, or checks specified here or otherwise approved shall be reinstated, pending further determination by the Division.

(3) Modifications. The Division may modify the frequency and standards contained in this section if found to be impractical.

(b) Dynamometer

(1) Coast Down Check.

(i) The calibration of each dynamometer shall be checked on a weekly basis by a dynamometer coast-down equivalent that in §86.118-78 (for reference see EOD Test Procedures TP-302A and TP-202) between the speeds of 55 to 45 mph, and between 22 to 18 mph. All rotating dynamometer components shall be included in the coast-down check for the inertia weight selected.

(ii) The base dynamometer and the base plus each prime inertia weight flywheel, if any, shall be checked with at least two horsepower settings within the normal range of the inertia weight. For dynamometers that use electrical inertia simulation and have a base inertia outside of the range of 3000 pounds to 4500 pounds, the coast-down check shall be conducted with at least two horsepower settings at the base inertia, and two settings at either 2500 pounds or 4500 pounds, whichever is furthest from the base inertia weight. For both mechanical flywheel dynamometers and electrical inertia simulation dynamometers, the horsepower settings selected shall correspond to a vehicle / engine category that matches the inertia weight selected for the coast-down test. Where the base inertia, or the base inertia plus the smallest flywheel results in a coast-down inertia of less than 2250 pounds, only one horsepower setting is required for the check.

(iii) The coast-down procedure shall be of a self motoring method. If the difference between the measured coast-down time and the theoretical coast-down time is greater than ±1 second on the 55 to 45 mph coast-down as calculated by §85.2234(b)(1)(iii)(A) or (B), official testing shall automatically be prevented, and corrective action shall be taken to bring the dynamometer into calibration. Official testing shall also automatically be prevented, and corrective action shall be taken to bring the dynamometer into calibration, if the difference between the measured coast-down time and the theoretical coast-down time for 22 to 18 mph is outside of the time window calculated by §85.2234(b)(1)(iii)(C) or (D). For tests using inertia weights of 8500 lbs. and above, if the difference between the measured coast-down time and the theoretical coast-down time is outside of the time window calculated by §85.2234(b)(1)(iii)(C) or (D) for the 22 mph to the 18 mph coast-down when substituting 0.27 HP for the allowable force-error (equivalent to 5.0 pounds-force at 20 mph), official testing shall automatically be prevented, and corrective action shall be taken to bring the dynamometer into calibration.

(A) The off-dynamometer target coast-down time at 50 mph ($DET_{@50\ mph\text{-}8}$) for dynamometers with 8.265 inch rolls shall be calculated as follows.

$$DET_{@50MPH\text{-}8} = \frac{\left(\frac{0.5 * ETW}{32.2}\right) * (V_{55}^2 - V_{45}^2)}{550 * (TRLHP_{@50mph} - GTRL_{@50mph\text{-}8})}$$

(B) The off-dynamometer target coast-down time at 50 mph ($DET_{@50\ mph\text{-}20}$) for dynamometers with 20.0 inch rolls shall be calculated as follows.

$$DET_{@50mph\text{-}20} = \frac{\left(\frac{0.5 * ETW}{32.2}\right) * (V_{55}^2 - V_{45}^2)}{550 * (TRLHP_{@50mph} - GTRL_{@50mph\text{-}20})}$$

(C) The maximum and minimum time limits for the off-dynamometer coast-down window at 20 mph ($DT_{Max\ @\ 20\ mph-8}$, $DT_{Min\ @\ 20\ mph-8}$) for dynamometers with 8.265 inch rolls shall be calculated by the following equations. The TRLHP and GTRL used in these calculations shall be determined from the same vehicle / engine category used to determine the 50 mph off-dynamometer target coast-down time. If the calculated maximum value ($DT_{Max\ @\ 20\ mph-8}$) exceeds twice the target value calculated for a specific vehicle / engine category ($DT_{Ave\ @\ 20\ mph-8}$), or if the maximum value is a negative number, a value equal to twice the target value shall be substituted for the maximum time limit.

$$DT_{Max@20mph-8} = \frac{\left(\frac{0.5 * ETW}{32.2}\right) * (V_{22}^2 - V_{18}^2)}{550 * (TRLHP_{@20mph} - GTRL_{@20mph-8} - 0.17HP)}$$

$$DT_{Ave@20mph-8} = \frac{\left(\frac{0.5 * ETW}{32.2}\right) * (V_{22}^2 - V_{18}^2)}{550 * (TRLHP_{@20mph} - GTRL_{@20mph-8})}$$

$$DT_{Min@20mph-8} = \frac{\left(\frac{0.5 * ETW}{32.2}\right) * (V_{22}^2 - V_{18}^2)}{550 * (TRLHP_{@20mph} - GTRL_{@20mph-8} + 0.17HP)}$$

(D) The maximum and minimum time limits for the off-dynamometer coast-down window at 20 mph ($DT_{Max\ @\ 20\ mph-20}$, $DT_{Min\ @\ 20\ mph-20}$) for dynamometers with 20.0 inch rolls shall be calculated by the following equations. The TRLHP and GTRL used in these calculations shall be determined from the same vehicle / engine category used to determine the 50 mph off-dynamometer target coast-down time.

$$DT_{Max@20mph-20} = \frac{\left(\frac{0.5 * ETW}{32.2}\right) * (V_{22}^2 - V_{18}^2)}{550 * (TRLHP_{@20mph} - GTRL_{@20mph-20} - 0.17HP)}$$

$$DT_{Min@20mph-20} = \frac{\left(\frac{0.5 * ETW}{32.2}\right) * (V_{22}^2 - V_{18}^2)}{550 * (TRLHP_{@20mph} - GTRL_{@20mph-20} + 0.17HP)}$$

(E) Where:

$DET_{@\ 50\ mph-dd}$ = Off-dynamometer target coast-down time (seconds) at 50 mph for a dynamometer with a roll diameter corresponding to the designator "dd"

$DT_{Max\ @\ 20\ mph-dd}$ = Upper off-dynamometer target coast-down time limit (seconds) at 20 mph for a dynamometer with a roll diameter corresponding to the designator "dd"

$DT_{Ave\ @\ 20\ mph\text{-}dd}$ = Off-dynamometer target coast-down time (seconds) at 20 mph for a dynamometer with a roll diameter corresponding to the designator "dd"

$DT_{Min\ @\ 20\ mph\text{-}dd}$ = Lower off-dynamometer target coast-down time limit (seconds) at 20 mph for a dynamometer with a roll diameter corresponding to the designator "dd"

$TRLHP_{@\ 50\ mph}$ = Track Road Load Horsepower at 50 mph for a specific vehicle engine category selected for the coast down check.

$TRLHP_{@\ 20\ mph}$ = Track Road Load Horsepower at 20 mph for the corresponding specific vehicle engine category selected for the 50 mph coast down check.

$GTRL_{@\ 50\ mph\text{-}dd}$ = Generic Tire/Roll Horsepower loss at 50 mph for a dynamometer with "dd" roll size, and corresponding to the specific vehicle engine category selected for the 50 mph coast down check.

$GTRL_{@\ 20\ mph\text{-}dd}$ = Generic Tire/Roll Horsepower loss at 20 mph for a dynamometer with "dd" roll size, and corresponding to the specific vehicle engine category selected for the 50 mph coast down check.

ETW = Equivalent Test Weight (i.e., inertia weight) in pounds corresponding to the specific vehicle engine category selected for the 50 mph coast down check.

V_{xx}^{2} = Velocity in feet per second corresponding to the mph value "xx"

0.17 HP = Horsepower representation of an allowable force-error of 3.3 pounds-force at 20 mph. This allowable force-error is approximately equivalent to a ± 2 second tolerance in the off-dynamometer target coast-down time at 50 mph for a dynamometer with 8.625" rolls when using a TRLHP computed from the EPA on-dynamometer target coast-down time. This force-error is approximately equivalent to a ± 1.25 second tolerance in the off-dynamometer target coast-down time at 50 mph for a dynamometer with 20.0" rolls.

(iv) The clock used to check the coast-down time shall be accurate to 0.1 percent of reading between 10 and 1000 seconds with a resolution of 0.01 seconds.

(v) The results of each dynamometer coast-down check performed shall be automatically computed and recorded on electronic media with a date and time stamp.

(2) Roll Speed. Roll speed and roll counts shall be checked each operating day by an independent means (e.g., photo tachometer). Deviations of greater than ±0.2 mph or a comparable tolerance in roll counts shall require corrective action. Alternatively, a redundant roll speed transducer independent of the primary transducer may be used in lieu of the daily comparison. Accuracy of redundant systems shall be checked monthly.

(3) Warm-Up. Dynamometers shall be in a warmed up condition for use in official testing. Warm-up is defined as sufficient operation that allows the dynamometer to meet the coast down time (within 3 seconds) identified for the specific dynamometer during calibration. The reference coast-down time shall be the value for 55 to 45 mph with the lightest inertia weight and lowest horsepower for that weight used during weekly calibrations. Alternatively, the reference coast-down time shall be the value for 22 to 18 mph with the lightest inertia weight and lowest horsepower for that weight used during weekly calibration, with a time standard of ±20%. Warm-up may be checked by comparing the measured parasitic losses at least 25 mph to reference values established during calibration.

(4) Acceptance Testing. Upon initial installation and prior to beginning official testing, the performance of each dynamometer and dynamometer design shall be verified for compliance with the requirements in §85.2226(a). Specific acceptance verification requirements are described in §85.2234(b)(4)(i) through §85.2234(b)(4)(v).

(i) Coast Down / Vehicle Loading Check Following Installation. The coast down performance of each dynamometer shall be checked to verify the ability of the dynamometer and dynamometer load setting system to meet dynamometer target coast down times prior to beginning official testing. The performance shall be checked by the procedure defined in §85.2234(b)(4)(i)(A) through §85.2234(b)(4)(i)(J), or by a comparable procedure approved by the Division.

(A) The dynamometer shall be warmed-up by the dynamometer manufacturer's procedure.

(B) At least three vehicle / engine categories shall be selected from the Look-Up table for vehicle loading. The vehicle / engine categories should cover the range of expected test vehicles.

(C) The dynamometer shall be set for the first vehicle/engine category selected based on the variables used to uniquely index the vehicle engine category (e.g., model year, manufacturer, model, number of cylinders, engine size, and transmission type).

(D) The dynamometer shall be coasted down from 65 mph to 5 mph with the settings pre-selected in §85.2234(b)(4)(i)(C).

(E) The 55 mph to 45 mph, and the 22 mph to 18 mph coast down times shall be recorded for the data collected in §85.2234(b)(4)(i)(D).

(F) The dynamometer shall be coasted down from 65 mph to 5 mph after having been adjusted for each of the other two vehicle engine categories, and the 55 mph to 45 mph, and the 22 mph to 18 mph coast down times shall be recorded for each coast-down.

(G) The coast-downs specified in §85.2234(b)(4)(i)(C) through §85.2234 (b)(4)(i)(F) shall be replicated for a total of three coast-down tests for each vehicle inertia category. The replications of the coast-downs for each vehicle engine category shall be run in random sequence.

(H) The off-dynamometer target coast-down time at 50 mph ($DET_{@\ 50\ mph\text{-}dd}$) for each vehicle / engine category shall be calculated as specified in §85.2234(b)(1)(iii)(A) or (B) for the applicable dynamometer roll size.

(I) The upper and lower off-dynamometer coast-down time limits at 20 mph ($DT_{Max\ @\ 20\ mph\text{-}dd}$, $DT_{Min\ @\ 20\ mph\text{-}dd}$) for each vehicle / engine category shall be calculated as specified in §85.2234(b)(1)(iii)(C) or (D) for the applicable dynamometer roll size.

(J) The dynamometer vehicle loading is considered acceptable if each measured 55 mph to 45 mph coast-down time for each vehicle / engine category tested is within ± 1 second of the off-dynamometer target coast-down time determined in (b)(4)(i)(H) above, and if each measured 22 mph to 18 mph coast-down time for each vehicle / engine category tested is within the off-dynamometer target coast-down time limits determined in (b)(4)(i)(I) above.

(ii) Vehicle Loading Check of Dynamometer Design. For each dynamometer design used, the Division shall obtain and maintain a report verifying the ability of the dynamometer design to properly load vehicles as specified in §85.2226(a). The dynamometer manufacturer may prepare the report. The report shall identify how each requirement in §85.2226(a) is performed by the specific dynamometer design used. In addition, where specific performance levels or characterizations are specified {e.g., §85.2226 (a)(2)(viii), §85.2226(2)(x), §85.2226(4)(ii) and §85.2226(a)(5)}, test data with supporting analysis verifying compliance shall be included. At a minimum, the test data shall include a comparison and analysis of the expected coast-down times versus the actual vehicle on-dynamometer coast-down times for at least three vehicles spanning the range of drive axle weights and horsepower. Actual track coast-down data and curves shall be available for the makes and models of vehicles selected from which the expected coast-down times shall be derived. The analysis shall also graphically compare the track horsepower curves to curves generated from the on-dynamometer coast-down testing. Reasons for variations in time, equivalent to one horsepower, between the expected coast-down times and the actual vehicle on-dynamometer coast-down times, or variations between the curves of more than one horsepower shall be explained in the report.

(iii) Alternative Coast Down / Vehicle Loading Check. This procedure may be used in lieu of the procedures in §85.2234(b)(4)(i). The coast down performance of each dynamometer shall be checked with at least two categories of vehicles to verify the ability of the dynamometer and dynamometer load setting system to meet dynamometer target coast down times. The coast down performance of each dynamometer design used shall be checked with at least 6 categories of vehicles to determine the ability of the dynamometer design to properly load the vehicle over the required speed range as defined in §85.2226(a)(2). The performance of the design shall be checked by the procedure defined §85.2234(b)(4)(ii)(A) through §85.2234(b)(4)(ii)(L), or by a comparable procedure proposed by the Division.

(A) The dynamometer shall be warmed-up by the dynamometer manufacturer's procedure, and the tires and drive train on the test car shall be warmed-up by operating the vehicle at 50 mph for 20 minutes. The tire pressure in the test vehicles shall be at 45 psi.

(B) The dynamometer indicated power (IHP) and inertia weight for the vehicle shall be selected for the test vehicle.

(C) The test vehicle shall be coasted down from 65 mph to 5 mph on the dynamometer with the settings pre-selected in §85.2234(b)(4)(i)(B).

(D) The 55 mph to 45 mph, and the 22 mph to 18 mph coast down times shall be recorded for the data collected in §85.2234(b)(4)(i)(C).

(E) The test vehicle shall again be coasted down from 65 mph to 5 mph on the dynamometer with the dynamometer power absorber reset to a load of zero.

(F) A speed versus horsepower equation of the form in §85.2226(a)(2)(iii) shall be determined for the data collected in §85.2234(b)(4)(i)(E).

(G) The test vehicle shall be removed from the dynamometer, and the dynamometer shall be coasted down from 65 mph to 5 mph with the dynamometer power absorber set to a load of zero.

(H) A speed versus horsepower equation of the form in §85.2226(a)(2)(ix) for parasitic losses (PLHP) shall be determined for the data collected in §85.2234(b)(4)(i)(G).

(I) The tire/roll interface losses shall be determined by subtracting the horsepower curve determined in §85.2234(b)(4)(i)(H) from the horsepower curve determined in §85.2234(b)(4)(i)(F). The tire loss curve (GTRL) shall be in the form specified in §85.2226(a)(2)(xiii).

(J) Repeat the steps in §85.2234(b)(4)(i)(B) through §85.2234(b)(4)(i)(I) to obtain a total of three sets of data for each test vehicle. The dynamometer and vehicle may be warmed-up as needed to meet the requirements in §85.2234(b)(4)(i)(A).

(K) For each test vehicle, compute the average 55 mph to 45 mph coast down time, the average 22 mph to 18 mph coast down time, and the average tire/roll interface loss curve as measured in §85.2234(b)(4)(i)(B) through §85.2234(b)(4)(i)(J).

(L) The dynamometer vehicle loading is considered acceptable if, for each test vehicle, the average values determined in §85.2234(b)(4)(i)(K) are within ±1 second of the 55 mph to 45 mph for the target time specified in §85.2226(a)(2)(ii), are within ±7 percent of the 22 mph to 18 mph that is calculated from §85.2226(a)(2)(iii) and §85.2226(a)(2)(iv), and within ±15 percent of a generic tire/roll loss curve for the category of vehicle.

(iv) Load Measuring Device Check. The load measuring device on each dynamometer shall be checked by a dead-weight method (or equivalent) at least six points across the range of loads used for vehicle testing. Physical checking weights shall be traceable to NIST standards to within ± 0.5 percent. Equivalent methods shall document the method used to verify equivalent accuracy. The accuracy of the interpreted value used for calculation or control shall be within ±1 percent of full scale.

(v) Vehicle Inertia Loading. The actual inertia applied to the vehicle by each inertia weight, in combination with the base inertia, shall be verified for each dynamometer to insure compliance with the requirements in §85.2226(a)(4)(i) or §85.2226(a)(4)(ii) as applicable.

(vi) Parasitic loss check between 8 and 12 mph. The coast down time of each dynamometer between 8 and 12 mph shall be verified for compliance with the requirements of §85.2226(a)(2)(x).

(vii) Speed and Distance Check. The performance of the speed and distance measuring system of each dynamometer shall be verified for compliance with the requirements of §85.2226(a)(5)(i). The ability to resolve acceleration as specified in §85.2226(a)(5)(i) need only be generically verified for the design used. If more than one design is used, each design shall be verified.

(viii) Warm-up System Check. The dynamometer warm-up system shall be checked for compliance with the requirements in §85.2234(b)(3) by conducting a coast down check immediately following completion of the warm-up specified by the dynamometer manufacturer or the system. The design of the warm-up system should be checked across the range of temperatures experience in-use, and particularly at the lower speeds.

(5) Coast-down Times. Following acceptance, 55 to 45 mph, and 22 to 18 mph coast-down times shall be determined for quality control purposes with the vehicle off the dynamometer for each inertia weight and for at least 2 horsepower settings within the normal range of the inertia weight as required in §85.2234(b)(1)(ii). These quality control values shall be determined when the dynamometer has been set to meet either the coast-down target times with the vehicle on the dynamometer (i.e., 55 to 45 mph and 22 to 18 mph), or the equation coefficients. The Division, may however, select different vehicle/engine categories to check coast-down times as in §85.2234(b)(4)(i) for audit purposes.

(c) Constant Volume Sampler

(1) Flow Calibration. The flow of the CVS shall be calibrated at six flow rates upon initial installation, 6 months following installation, and every 12 months thereafter. The flow rates shall include the nominal rated flow-rate and a rate below the rated flow-rate for both critical flow venturis and subsonic venturis, and a flow-rate above the rated flow for sub-sonic venturis. The flow calibration points shall cover the range of variation in flow that typically occurs when testing. A complete calibration shall be performed following repairs to the CVS that could affect flow.

(2) System Check. CVS flow calibration at the nominal CVS design flow shall be checked once per operating day using a procedure that identifies deviations in flow from the true value. A procedure equivalent to that in §86.119(c) shall be used. Deviations greater than ±4% shall result in automatic lockout of official testing until corrected.

(3) Cleaning Flow Passages. The sample probe shall be checked at least once per month and cleaned if necessary to maintain proper sample flow. CVS venturi passages shall be checked once per year and cleaned if necessary.

(4) Probe Flow. The indicator identifying the presence of proper probe flow for the system design (e.g., proportional flow for CFV systems, minimum flow for time correlation of different analyzers) shall be checked on a daily basis. Lack of proper flow shall require corrective action.

(5) Leak Check. The vacuum portion of the sample system shall be checked for leaks on a daily basis and each time the system integrity is violated (e.g., changing a filter).

(6) Bag Sample Check. On a quarterly basis, vehicle exhaust shall be collected in sample bags with simultaneous integrated measurement of the sample. At least one bag each for Phase 1 and for Phase 2 of the transient test cycle shall be conducted. Differences between the two measurement systems greater than 10% shall result in system lockout until corrective action is taken. For the purposes of acceptance testing, the differences shall be no greater than 5%.

(7) Response Time Check. The response time of each analyzer shall be checked upon initial installation, during each check for compliance with §85.2234(c)(6), after each repair or modification to the flow system that would reasonably be expected to affect the response time, and as determined by the division. The check shall include the complete sample system from the sample probe to the analyzer. Statistical process control shall be used to monitor compliance and establish fit for use limits based on the requirements in §85.2226(c). At a minimum, response time measurements that deviate significantly from the average response time for all CVS systems designed to the same specification in the program shall require corrective action before testing may resume.

(8) Mixing Tee Acceptance Test.

(i) The design of the mixing tee shall be evaluated by running the transient driving cycle on at least two vehicles, representing the high and low ends of engine displacement and inertia. Changes in the static tailpipe pressure with and without CVS, measured on a second-by-second basis within 3 inches of the end of the tailpipe, shall not exceed ±1.0 inch of water.

(ii) The ability of the mixing tee design to capture all of the exhaust as a vehicle moves laterally from one extreme position on the dynamometer to the other extreme shall be evaluated with back-to-back testing of three vehicles, representing the high and low ends of engine displacement and inertia. The back-to-back testing shall be done with the mixing tee at the tailpipe and with an airtight connection to the tailpipe (i.e., the mixing tee will be effectively moved downstream, as in typical FTP testing). The difference in carbon-balance fuel economy between the mixing tee located at the vehicle and the positive connection shall be no greater than 5%.

(iii) The design of the dual exhaust system shall be evaluated with back-to-back testing of three vehicles, representing the high and low ends of engine displacement and inertia, with an airtight connection to the tailpipe (i.e., the mixing tee will be effectively moved downstream, as in typical FTP testing, for these qualification tests). The difference in carbon-balance fuel economy between the two methods shall be no greater than 5%.

(d) Analysis System

(1) Calibration Curve Generation.

(i) Upon initial installation, calibration curves shall be generated for each analyzer. If an analyzer has more than one measurement transducer, each transducer shall be considered as a separate analyzer in the analysis system for the purposes of curve generation and analysis system checks.

(ii) The calibration curve shall consider the entire range of the analyzer as one curve.

(iii) A ten (10) point equal distribution calibration curve is required of each analyzer. The calibration zero gas shall be used to set the analyzer to zero.

(iv) Gas dividers may be used to obtain the intermediate points for the general range classifications specified.

(v) The calibration curves generated shall be a polynomial of the best fit and no greater than 4^{th} order, and shall fit the data within 2.0% at each calibration point as specified in §86.121-90, §86.122-78, §86.123-78, and §86.124-78.

(vi) Each curve shall be verified for each analyzer with a confirming calibration standard between 40-80% of full scale that is not used for curve generation. Each confirming standard shall be measured by the curve within 2.5%.

(2) Spanning Frequency. The zero and up-scale span points shall be checked at 2 hour intervals following the daily mid-scale curve check specified in §85.2234(d)(4) and adjusted if necessary. If the up-scale span point drifts by more than 2.0% from the previous check or, for the first check performed after the daily calibration check described in §85.2234(d)(4), from the daily check official testing shall be prevented and corrective action shall be taken to bring the system into compliance. If the zero point drifts by more than 2 ppm HC, 1 ppm NOx, 10 ppm CO, or 40 ppm CO2, official testing shall be prevented and corrective action shall be taken to bring the system into compliance. Or, the unit may be zeroed prior to each test.

(3) Limit Check. The tolerance on the adjustment of the up-scale span point shall be 0.4% of point. A software algorithm to perform the zero and span adjustment and subsequent calibration curve adjustment shall be used. Cumulative software up-scale zero and span adjustments greater than ±10% from the latest calibration curve shall cause official testing to be prevented and corrective action shall be taken to bring the system into compliance.

(4) Daily Calibration Checks. The curve for each analyzer shall be checked and adjusted to correctly read zero using a working zero gas, and an up-scale span gas within the tolerance in §85.2234(d)(3), and then by reading a mid-scale span gas within 2.5% of point, on each operating day prior to vehicle testing. If the analyzer does not read the mid-scale span point within 2.5% of point, the analyzer shall automatically be prevented from official testing. The up-scale span

gas concentration for each analyzer shall correspond to approximately 80% of full scale, and the mid-point concentration shall correspond to approximately 15% of full scale.

(5) Weekly NOx Convertor Checks. The convertor efficiency of the NO_2 to NO convertor shall be checked on a weekly basis or as determined by the division. The check shall be equivalent to §86.123-78 (for reference see EOD Form 305-01) except that the concentration of the NO gas shall be in the range of 100-300 ppm. Alternative methods may be used if approved by the Division.

(6) Weekly NO/NOx Flow Balance. The flow balance between the NO and NOx test modes shall be checked weekly or as determined by the division. The check may be combined with the NOx convertor check as illustrated in EPA NVFEL Form 305-01.

(7) Monthly Calibration Checks. The basic calibration curve shall be verified monthly by the same procedure used to generate the curve in §85.2234(d)(1), and to the same tolerances.

(8) FID Check.

(i) Upon initial operation, and after maintenance to the detector, each FID shall be checked, and adjusted if necessary, for proper peaking and characterization using the procedures described in SAE Paper No. 770141 or by analyzer manufacturer recommended procedures.

(ii) The response of each FID to a methane concentration of approximately 50 ppm CH_4 shall be checked once per month. If the response is outside of the range of 1.00 to 1.30, corrective action shall be taken to bring the FID response within this range. The response shall be computed by the equation in §85.2234(d)(9)(iii).

(iii) Ratio of Methane Response =

(9) Integrator Checks. Upon initial operation, emissions from a vehicle with transient cycle test values between 60% and 400% of the 1984 LDGV standard shall be simultaneously sampled by the normal integration method and by the bag method in each system. The data from each method shall be put into a historical data base for determining normal and deviant performance for each test system. Specific deviations between the integrator and bag readings exceeding ±10% shall require corrective action.

(10) Cross-Checks. NOT APPLICABLE On a quarterly basis, and whenever gas bottles are changed, each analyzer in a given facility shall analyze a sample of a test gas. The test gas shall be independent of the gas used for the daily calibration check in §85.2234(d)(4), in independent bottles. The same test gas, or gas mixture shall be used for all analyzers. The concentration of the gas shall be one of three values corresponding to approximately 0.5 to 3 times the cutpoint (in gpm) for 1984 and later model year vehicles for the constituent. One of the three

values shall be at the lower end of the range, another shall be at the higher end of the range, and the other shall be near the middle of the range. The values selected shall be rotated in a random manner for each cross-check. The value of the checking sample may be determined by a gas divider. The deviation in analysis from the concentration of the checking sample for each analyzer shall be recorded and compared to the historical mean and standard deviation for the analyzers at the network and at all facilities. Any reading exceeding 3 sigma shall cause the analyzer to be placed out of service.

(11) Interference, Laboratory Testing. The design of each CO, CO_2, and NOx analyzer shall be checked for water vapor interference prior to initial service. The interference limits in this paragraph shall apply to analyzers used with a CVS of 700 SCFM or greater. For analyzers used with lower flow rate CVS units, the allowable interference response shall be proportionately adjusted downward.

(i) CO Analyzer. A gas mixture of 4% CO_2 in N_2 bubbled through water with a saturated-mixture temperature of 40°C shall produce a response on the CO analyzer of no greater than 15 ppm at 40°C. Also, a gas mixture of 4 percent CO_2 in N_2 shall produce a response on the CO analyzer of no greater than 10 ppm at 40°C.

(ii) CO2 Analyzer. A calibration zero gas bubbled through water with a saturated-mixture temperature of 40°C shall produce a response on the CO_2 analyzer of no greater than 60 ppm.

(iii) NOx Analyzer. A calibration zero gas bubbled through water with a saturated-mixture temperature of 40°C shall produce a response on the NOx analyzer of no greater than 1 ppm. Also, a gas mixture of 4 percent CO2 in either N2 or air shall produce a response on the NOx analyzer of no greater than 1.0 ppm at 40°C.

(12) Interference -- Field Testing. Each CO, CO_2, and NOx analyzers shall be checked for water vapor interference prior to initial service, and on a yearly basis thereafter. The in-field check prior to initial service and the yearly checks shall be performed on a high ambient temperature summer day (or simulated conditions). For analyzers used with lower flow rate CVS units, the allowable interference response shall be proportionately adjusted downward. The allowable interference level shall be adjusted to coincide with the saturated-mixture temperature used. For the CO analyzer, a rejection ratio of 9,000 to 1 shall be used for this calculation. A ratio of 2000 to 1 shall be used for CO_2 analyzers. A ratio of 90,000 to 1 shall be used for NOx analyzers.

(e) **Gases**

Calibration, Working and Span Gases Shall Conform to Regulation 11 Appendix B

(f) **Quality Control Data Files for Individual Test Systems.** In general, quality files control for individual test systems shall include parameters that will allow the cause for abnormal performance of a test system to be pinpointed to individual systems or components. Test system control charts shall include at a minimum:

(i) Overall number of voided tests

(ii) Number of voided tests by type

(iii) Level of difference between theoretical and measured coast-down times

(iv) Level of difference between theoretical and measured CVS flow

(v) Level of up-scale span change from last up-scale span (not required if software corrections are tracked)

(vi) Level of mathematical or software correction to the calibration curve as a result of an up-scale span change (if used)

(vii) Level of difference between the analyzer response to the daily cross-check, and the test gas concentration

(viii) Level of difference between the integrated measurements and the bag measurements

(ix) The system response time

(x) Level of the FID CH_4 response ratio

(xi) Level of the ambient background concentrations

(xii) The average, median, 10^{th} percentile and 90^{th} percentile of the composite emissions (HC, CO, CO_2, and NOx) measured over the defined periodic basis

(xiii) Average number of passing vehicles, and average number of failing vehicles over the defined periodic basis

(xiv) Level of difference between theoretical or measured values for other parameters measured during quality assurance procedures

Test Report

(a) Acceptance Test Reporting for System Evaluation

(1) Test Types and Standards. The test report shall indicate the types of tests performed on the vehicle and the test standards for each. Test standards shall be displayed to the appropriate number of significant digits as in §85.2205(a). The reported standards shall be the composite test standards.

(2) Test Scores. The test report shall show the scores for each test performed. Test scores shall be displayed to the same number of significant digits as the standards.

(3) Transient Mode Test Scores. The reported score for the Transient Mode shall be in units of grams per mile and shall be selected based upon the following:

(i) If the emissions of any exhaust component of the composite Transient Test are below the applicable standard in Part F of this regulation, then the vehicle shall pass for that constituent and the composite score shall be reported.

(ii) If the emissions of any exhaust component on the composite Transient Test exceed the applicable standard in Part F of this regulation, but are below the Phase 2 standard, then the vehicle shall pass for that component and the Phase 2 score shall be reported.

Terms

(a) Definitions

(1) Track coast-down target time: The new vehicle certification track coast-down time between 55 and 45 mph.

(2) Road load horsepower: The power required for a vehicle to maintain a given constant speed taking into account power losses due to such things as wind resistance, tire losses, bearing friction, etc.

(3) Tier 1: New gaseous and particulate tailpipe emission standards for use in certifying new light duty vehicles and light duty trucks phased in beginning with the 1994 model year.

(1) CVS hose: The hose, connecting to the tailpipe of the vehicle, that carries exhaust and dilution air to the stationary portion of the CVS system.

(1) The Division: Colorado Department of Public Health and Environment, Air Pollution Control Division.

(5) **(b) Abbreviations**

(1)	CFV:	Critical flow venturi
(2)	CH_4:	Methane
(3)	CO_2:	Carbon dioxide
(4)	CO:	Carbon monoxide
(5)	CRM:	Certified reference material
(6)	CVS:	constant volume sampler
(7)	FID:	Flame ionization detector
(8)	gpm:	Grams per mile
(9)	GVWR:	Gross Vehicle Weight Rating
(10)	HC:	Hydrocarbons
(11)	HDGT:	Heavy-Duty Gasoline-powered Truck greater than 8500 pounds GVWR
(12)	hp:	horsepower
(13)	Hz:	cycles per second (Hertz)
(14)	I/M:	Inspection and Maintenance
(15)	IW:	Inertia weight
(16)	LDGT1:	Light-Duty Gasoline-powered Truck from 0 to 6000 pounds GVWR
(17)	LDGT2:	Light-Duty Gasoline-powered Truck from 6001 to 8500 pounds GVWR
(18)	LDGV:	Light-Duty Gasoline-powered Vehicle
(19)	LVW	Loaded Vehicle Weight
(20)	mph:	Miles per hour
(21)	NDIR:	non-dispersive infrared
(22)	NIST:	National Institute for Standards and Technology
(23)	NO_2:	Nitrogen dioxide
(24)	NO:	Nitrogen oxide
(25)	NOx:	Oxides of nitrogen
(26)	NVFEL:	National Vehicle and Fuel Emissions Laboratory
(27)	Obmph:	Observed dynamometer speed in mph of the loading roller, if rolls are not coupled
(28)	PLHP:	Parasitic horsepower loss at the observed dynamometer speed in mph
(29)	ppm:	parts per million by volume
(30)	ppmC:	parts per million, carbon

(31)	psi:	Pounds per square inch
(32)	RFP:	Request for Proposal
(33)	RLHP	Road Load Horsepower
(34)	rpm:	revolutions per minute
(1)	SCFM:	standard cubic feet per minute
(1)	SEO:	square edged orifice
(37)	SPC:	Statistical process control
(38)	SRM:	Standard reference material
(39)	SSV:	Subsonic venturi
(40)	TRLHP:	Track road-load horsepower