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IM240 & Evap Technical Guidance

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IM240 & Evap Technical Guidance

Transportation and Regional Programs Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

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This technical report does not necessarily represent final EPA decisions or positions. It is intended to present technical analysis of issues using data which are currently available. The purpose in the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments which may form the basis for a final EPA decision, position, or regulatory action.

Introduction

Introduction

This document is the successor to the August 1998 version of the EPA “IM240 & Evap Technical Guidance” and incorporates changes made since its publication. The following changes have been incorporated in this release of the EPA I/M technical guidance:

1) All references to the EPA evaporative emission purge test have been removed. Standards, procedures, specifications, and quality control practices are described in the August 1998 technical guidance.

2) A spreadsheet and example for usage of the Modal Fast Pass concept have been posted with the IM240 & Evap Technical Guidance on the EPA I/M web site..

3) K1 and K2 coefficients have been changed in 85.2205(b)(3)(iv)(E) to make them technically correct.

4) The exponent in the humidity correction factor in 85.2205(b)(3)(xi)(F) has been corrected for a typographical error.

5) References to procedures for treatment of OBD II evaporative emission controlled vehicles have been revised to state that guidance for these vehicles will be published in a separate document, not a revision of the IM240 & Evap Technical Guidance.

6) The standard for the fuel inlet pressure test, 85.2205(d)(2)(i) has corrected a typographical error. The value “8" has been changed to “6.”

7) 85.2222(a)(2) has added a sentence stating fuel volatility is also a factor contributing to test variability when conducting the fuel inlet pressure test.

8) 85.2226(a)(3)(iii) has been revised to specify response time measurements at 2000, base inertia, and 5500 pounds of inertia.

9) 85.2227(b)(1)(i) has been added to specifically permit the use of flow based leak detection methods, but no standards have been proposed at present.

10) The text in 85.2227(c)(1)(iv) has been revised to clarify the term “automated.” The new wording states automatic operation means automated measurement of the pass/fail condition <u>and</u> a requirement for a real time data link.

11) Paragraphs (ii) and (iii) of 85.2234 have been modified to provide more flexible load settings at 50 and 20 mph to achieve longer and more measurable coast down times. The 22 to 18 mph coastdown limit has been changed to ± 6 seconds.

12) The 0.4% of point tolerance in 85.2234(d)(3) has been revised to ± 2% of point of a specific analyzer range, and the first sentence is modified to state its intent is to apply to the initial setting of a span point.

13) Paragraph 4 of 85.2234(g)(4) has been revised to state that driving trace quality is an example of how control charts for individual inspectors may used.

14) An equation has been added to 85.2239(b)(6) to define how “gpme” is calculated.

15) Appendix I, Derivation of GTRL Coefficients has been revised to clarify its content, and make it more compatible with terms and equations provided by Sierra Research in the supporting documentation when the EPA I/M Look-up Table is revised.

§85.2205 Test Standards

(a) IM240 Emission Standards

(1) Two Ways to Pass Standards. If the corrected, composite emission rates calculated in §85.2205(b) exceed the standards for any exhaust component, additional analysis of test results shall look at the second phase of the driving cycle separately. Phase 2 shall include second 94 through second 239. Second-by-second emission rates in grams, and composite emission rates in grams per mile for Phase 2 and for the entire test shall be recorded for each gas. If the composite emission level is equal to or below the composite standard, or if the Phase 2 grams per mile emission level is equal to or below the applicable Phase 2 standard, then the vehicle shall pass the test for that exhaust component.

(2) Start-up Standards. Start-up standards should be used during the first two years of program operation. Tier 1 standards are recommended for 1996 and newer vehicles and may be used for 1994 and newer vehicles certified to Tier 1 standards as well. The following exhaust emissions standards, in grams per mile, are recommended:

(i) Light Duty Vehicles.

Model Years	Hydrocarbons		Carbon Monoxide		Oxides of Nitrogen	
	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2
1996+	0.80	0.50	15.0	12.0	2.0	2.0
1991-1995	1.20	0.75	20.0	16.0	2.5	2.5
1983-1990	2.00	1.25	30.0	24.0	3.0	3.0
1981-1982	2.00	1.25	60.0	48.0	3.0	3.0
1980	2.00	1.25	60.0	48.0	6.0	6.0
1977-1979	7.50	5.00	90.0	72.0	6.0	6.0
1975-1976	7.50	5.00	90.0	72.0	9.0	9.0
1973-1974	10.0	6.00	150	120	9.0	9.0
1968-1972	10.0	6.00	150	120	10.0	10.0

(ii) High-Altitude Light Duty Vehicles.

Model Years	Hydrocarbons		Carbon Monoxide		Oxides of Nitrogen	
	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2
1983-1984	2.00	1.25	60.0	48.0	3.0	3.0
1982	2.00	1.25	75.0	60.0	3.0	3.0

(iii) Light Duty Trucks (0 - 6000 pounds GVWR).

Model Years	Hydrocarbons		Carbon Monoxide		Oxides of Nitrogen	
	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2
1996+						
(≤3750 LVW)	0.80	0.50	15.0	12.0	2.0	2.0
(>3750 LVW)	1.00	0.63	20.0	16.0	2.5	2.5
1991-1995	2.40	1.50	60.0	48.0	3.0	3.0
1988-1990	3.20	2.00	80.0	64.0	3.5	3.5
1984-1987	3.20	2.00	80.0	64.0	7.0	7.0
1979-1983	7.50	5.00	100	80.0	7.0	7.0

1975-1978	8.00	5.00	120	96.0	9.0	9.0
1973-1974	10.0	6.00	150	120	9.0	9.0
1968-1972	10.0	6.00	150	120	10.0	10.0

(iv) High-Altitude Light Duty Trucks (0 - 6000 pounds GVWR).

Model Years	Hydrocarbons		Carbon Monoxide		Oxides of Nitrogen	
	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2
1991+	3.00	2.00	70.0	56.0	3.0	3.0
1988-1990	4.00	2.50	90.0	72.0	3.5	3.5
1984-1987	4.00	2.50	90.0	72.0	7.0	7.0
1982-1983	8.00	5.00	130	104	7.0	7.0

(v) Light Duty Trucks (6001 - 8500 pounds GVWR).

Model Years	Hydrocarbons		Carbon Monoxide		Oxides of Nitrogen	
	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2
1996+						
(≤5750 ALVW)	1.00	0.63	20.0	16.0	2.5	2.5
(>5750 ALVW)	2.40	1.50	60.0	48.0	4.0	4.0
1991-1995	2.40	1.50	60.0	48.0	4.5	4.5
1988-1990	3.20	2.00	80.0	64.0	5.0	5.0
1984-1987	3.20	2.00	80.0	64.0	7.0	7.0
1979-1983	7.50	5.00	100	80.0	7.0	7.0
1975-1978	8.00	5.00	120	96.0	9.0	9.0
1973-1974	10.0	6.00	150	120	9.0	9.0
1968-1972	10.0	6.00	150	120	10.0	10.0

(vi) High-Altitude Light Duty Trucks (6001 - 8500 pounds GVWR).

Model Years	Hydrocarbons		Carbon Monoxide		Oxides of Nitrogen	
	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2
1991+	3.00	2.00	70.0	56.0	4.5	4.5
1988-1990	4.00	2.50	90.0	72.0	5.0	5.0
1984-1987	4.00	2.50	90.0	72.0	7.0	7.0
1982-1983	8.00	5.00	130	104	7.0	7.0

(vii) Heavy-Duty Trucks (greater than 8500 pounds GVWR).[1]

Model Years	Hydrocarbons		Carbon Monoxide		Oxides of Nitrogen	
	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2
1998+	2.00	1.30	30.0	24.0	4.0	4.0
1991-1997	3.00	1.90	60.0	48.0	6.0	6.0
1987-1990	3.00	1.90	60.0	48.0	8.0	8.0

[1] The heavy-duty truck standards provided here were calculated using new vehicle certification standards and have not been subjected to field testing. This document provides no other guidance on heavy duty truck testing. Thus, anyone interested in performing IM240 tests on heavy-duty trucks should proceed with appropriate caution.

1985-1986	5.00	3.10	75.0	60.0	8.0	8.0
1979-1984	6.00	3.80	100.0	80.0	8.0	8.0
1974-1978	10.0	6.30	150.0	120.0	10.0	10.0
1970-1973	10.0	6.30	175.0	140.0	10.0	10.0
pre-1970	20.0	12.50	200.0	160.0	15.0	15.0

(3) Final Standards. The following exhaust emissions standards, in grams per mile, are recommended for vehicles tested in the calendar years 1997 and later. Tier 1 standards are recommended for all 1996 and newer vehicles but may be used for 1994 and newer vehicles.

(i) Light Duty Vehicles.

Model Years	Hydrocarbons		Carbon Monoxide		Oxides of Nitrogen	
	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2
1996+	0.60	0.40	10.0	8.0	1.5	1.5
1983-1995	0.80	0.50	15.0	12.0	2.0	2.0
1981-1982	0.80	0.50	30.0	24.0	2.0	2.0
1980	0.80	0.50	30.0	24.0	4.0	4.0
1977-1979	3.00	2.00	65.0	52.0	4.0	4.0
1975-1976	3.00	2.00	65.0	52.0	6.0	6.0
1973-1974	7.00	4.50	120	96.0	6.0	6.0
1968-1972	7.00	4.50	120	96.0	7.0	7.0

(ii) High-Altitude Light Duty Vehicles.

Model Years	Hydrocarbons		Carbon Monoxide		Oxides of Nitrogen	
	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2
1983-1984	1.20	0.75	30.0	24.0	2.0	2.0
1982	1.20	0.75	45.0	36.0	2.0	2.0

(iii) Light Duty Trucks (0 - 6000 pounds GVWR).

Model Years	Hydrocarbons		Carbon Monoxide		Oxides of Nitrogen	
	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2
1996+						
(≤3750 LVW)	0.60	0.40	10.0	8.0	1.5	1.5
(>3750 LVW)	0.80	0.50	13.0	10.0	1.8	1.8
1988-1995	1.60	1.00	40.0	32.0	2.5	2.5
1984-1987	1.60	1.00	40.0	32.0	4.5	4.5
1979-1983	3.40	2.00	70.0	56.0	4.5	4.5
1975-1978	4.00	2.50	80.0	64.0	6.0	6.0
1973-1974	7.00	4.50	120	96.0	6.0	6.0
1968-1972	7.00	4.50	120	96.0	7.0	7.0

(iv) High-Altitude Light Duty Trucks (0 - 6000 pounds GVWR).

Model Years	Hydrocarbons		Carbon Monoxide		Oxides of Nitrogen	
	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2
1988+	2.00	1.25	60.0	48.0	2.5	2.5
1984-1987	2.00	1.25	60.0	48.0	4.5	4.5

1982-1983	4.00	2.50	90.0	72.0	4.5	4.5

(v) Light Duty Trucks (6001 - 8500 pounds GVWR).

Model Years	Hydrocarbons		Carbon Monoxide		Oxides of Nitrogen	
	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2
1996+						
(≤5750 ALVW)	0.80	0.50	13.0	10.0	1.8	1.8
(>5750 ALVW)	0.80	0.50	15.0	12.0	2.0	2.0
1988-1995	1.60	1.00	40.0	32.0	3.5	3.5
1984-1987	1.60	1.00	40.0	32.0	4.5	4.5
1979-1983	3.40	2.00	70.0	56.0	4.5	4.5
1975-1978	4.00	2.50	80.0	64.0	6.0	6.0
1973-1974	7.00	4.50	120	96.0	6.0	6.0
1968-1972	7.00	4.50	120	96.0	7.0	7.0

(vi) High-Altitude Light Duty Trucks (6001 - 8500 pounds GVWR).

Model Years	Hydrocarbons		Carbon Monoxide		Oxides of Nitrogen	
	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2
1988+	2.00	1.25	60.0	48.0	3.5	3.5
1984-1987	2.00	1.25	60.0	48.0	4.5	4.5
1982-1983	4.00	2.50	90.0	72.0	4.5	4.5

(vii) Heavy-Duty Trucks (greater than 8500 pounds GVWR).

Model Years	Hydrocarbons		Carbon Monoxide		Oxides of Nitrogen	
	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2
1998+	2.00	1.30	30.0	24.0	4.0	4.0
1991-1997	2.00	1.30	40.0	32.0	5.0	5.0
1987-1990	2.00	1.30	40.0	32.0	6.0	6.0
1985-1986	3.00	1.90	50.0	40.0	6.0	6.0
1979-1984	5.00	3.10	75.0	60.0	6.0	6.0
1974-1978	10.0	6.30	150.0	120.0	10.0	10.0
1970-1973	10.0	6.30	175.0	140.0	10.0	10.0
pre-1970	20.0	12.50	200.0	160.0	15.0	15.0

(4) Fast-Pass. Vehicles may be fast-passed using the following algorithm.

(i) Fast-Pass Algorithm. Beginning at second 30 of the driving cycle, cumulative second-by-second emission levels for each second, calculated from the start of the cycle in grams, shall be compared to the cumulative fast-pass emission standards for the second under consideration. For exhaust components subject to Phase 2 standards, cumulative second-by-second emission levels calculated in grams from second 109 forward shall be compared to cumulative second-by-second fast-pass Phase 2 emission standards for the second under consideration.

(ii) Fast-Pass Standards. A vehicle shall pass the IM240 for a given exhaust component if either of the following conditions occur:

(A) cumulative emissions of each exhaust are below the full cycle fast-pass standard for the second under consideration; or,

(B) at second 109 and later, (if the exhaust component is subject to Phase 2 standards) cumulative Phase 2 emissions of each exhaust component are below the Phase 2 fast-pass standards for the second under consideration;

(iii) Fast-Pass End of Test. Testing may be terminated when fast-pass criteria are met for all subject exhaust components.

(iv) Applicability of Fast-Pass Standards. If a fast-pass determination cannot be made for all subject exhaust components before the driving cycle ends, the pass/fail determination for each component shall be based on composite or Phase 2 emissions over the full driving cycle as described in §85.2205(a)(1).

(v) Fast-Pass Algorithms. Vehicles may be fast-passed using other approaches if they are approved by the Administrator. States are encouraged to develop and use equations to define fast-pass standards for each composite emission standard rather than using tabular standards for each second of the test.

EPA-developed, tabular, fast-passed standards are included in Appendix A.

Fast-pass standards developed by Radian for Colorado are included in Appendix B.

Appendix C contains fast-pass standards generated by EPA for Wisconsin at the state's request. This was done to allow the state to move toward implementing final IM240 standards.

Appendix D contains fast-pass guidelines and 0.8 g/mi HC composite standards along with 0.5 g/mi HC Phase 2 cut points developed by Sierra Research under contract 68-C4-0056 Work Assignment 2-04. A complete listing of the modal regression coefficients would be too large to print in an appendix; however, the description in Appendix D is intended to provide background information and the rational behind this methodology. A complete series of coefficients are available on EPA's web site.

(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 §85.2205(b)(1)(i):

(i) Composite gpm $= \sum_{s=0}^{s} emissions(g) \Big/ \sum_{s=0}^{s} distance(miles)$

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: $HC_{mass} = V_{mix} * Density_{HC} * \frac{HC_{conc}}{1,000,000}$

(ii) Carbon Monoxide mass: $CO_{mass} = V_{mix} * Density_{CO} * \frac{CO_{conc}}{1,000,000}$

(iii) Oxides of Nitrogen mass: NOxmass $= V_{mix} * Density_{NO2} * K_H * \frac{NO_{conc}}{1,000,000}$

(iv) Carbon Dioxide mass: CO2mass $= V_{mix} * Density_{CO2} * \frac{CO2_{conc}}{100}$

(3) Meaning of Terms.

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

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

(iii) $Density_{HC}$ = 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.

(iv) HC_{conc} = Average hydrocarbon concentration per second of the dilute exhaust sample corrected for background, in ppm carbon equivalent, i.e., equivalent propane * 3.

(A) $HC_{conc} = HC_e - HC_d\,(1 - \frac{1}{DF})$ Where:

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

(C) HC_d = Background hydrocarbon concentration of the dilution air, in ppm carbon equivalent.

(D) $$DF = \frac{13.4}{CO2_e + (HC_e + CO_e) * 10^{-4}}$$

This is calculated on a second-by-second basis, where CO_2 is measured in % and HC and CO are measured in ppm. Note this DF does not account for pollutants in the background air and becomes less accurate as the air-fuel ratio of the vehicle deviates from stoichiometric.

(E) $$DF_{alt} = \frac{100 - K1(CO2_d) - K2(CO_d) - K3(HC_d)}{K1(CO2_e - CO2_d) + K2(CO_e - CO_d) + K3(HC_e - HC_d)}$$

This method of calculating DF is also done on a second-by-second basis and accounts for pollutants in the background air as well as being more accurate than the method in (D) above when the vehicle deviates from stoichiometric operation. All concentrations are expressed in volume percent and the values of the constants for gasoline fuel are: K1 = 7.4806, K2 = 5.5936, and K3 = 57.0945. Appendix E contains additional information on this subject.

If raw emission scores are being determined from dilute measurements, EPA recommends the use of this method for calculating DF.

(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, corrected for background, water vapor, and CO_2 extraction, in ppm.

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

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

(C) CO_d = Background carbon monoxide concentration of the dilution air, 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, corrected for background in ppm.

(A) $NO_{xconc} = NO_{xe} - NO_{xd} \left(1 - \frac{1}{DF}\right)$

(B) NO_{xe} = Oxides of nitrogen concentration of the dilute exhaust sample, in ppm.

(C) NO_{xd} = Background oxides of nitrogen concentration of the dilution air, in ppm.

(xi) K_H = humidity correction factor

(A) Standard Method

$$K_H = \frac{1.0}{1.0 - 0.0047 * (H - 75.0)}$$

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

$$= \frac{43.478 * R_a * P_d}{P_b - (P_d * \frac{R_a}{100})}$$

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

(D) P_d = Saturated vapor pressure, mm Hg at the ambient dry bulb temperature.

(E) P_b = Barometric pressure, mm Hg.

(F) Revised method[2]

$$K_H = e^{[0.004977(H-75)-.004447(T-75)]}$$

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

(H) T = Temperature in °F.

NOTE: If the calculated K_H using either method of calculation is greater than 2.19, the value of K_H shall be set at 2.19.

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

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

(xv) CO_{2conc} = Average carbon dioxide concentration per second of the dilute exhaust sample, corrected for background, in percent.

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

(B) CO_{2d} = Background carbon dioxide concentration of the dilution air, in percent.

(4) Negative Values. Negative gram per second readings shall be integrated as zero and recorded as such. Negative values measured for ambient background concentrations (HC_d, CO_d, CO_{2d}, and NO_{xd}) used in 85.2205(b)(3) shall be calculated as zero and recorded as such.

(5) Determination of Raw Exhaust Concentrations from IM240 Results. Although the IM240 is a mass-based test, it is possible to estimate tailpipe concentrations from the dilute measurements for those vehicles only required to undergo an idle test. One method for performing this

[2]This revised method for calculating K_H as a function of both T and H is based on work performed by Sierra Research under contract 68-C4-0056, Work Assignment 2-04. If the calculated value of K_H exceeds 2.19, the value of K_H shall be set to 2.19. This analysis used the same MY69, 5-vehicle sample employed for the original K_H factor study that resulted in the current CFR standard K_H calculation method (listed in (xi)(A) above). However, in many cases IM testing occurs outside the temperature limits set by the CFR for the standard method; therefore, at this time EPA recommends using the revised method when testing above 86°F.

calculation can be found in SAE manuscript 980678. Additional clarification on this can be found in Appendix E.

(c) Evaporative System Pressure Test Standards

The methods described below are applicable to pre OBD II evaporative emission controlled vehicles. OBD II vehicles equipped with evaporative control monitors and certified to the enhanced evaporative emission standards are being phased-in with the 1996 through 1998 model years. Those vehicles must be tested using either OBD II scan tools, by measuring pressure loss through an evaporative emission "service port," or by following vehicle manufacturer specific instruction to avoid damaging rigid vapor lines which are prevalent on many vehicles equipped with enhanced evaporative emission control systems. Procedures for using OBD II scan tools will be published in a separate document.

All I/M programs conducting a pressure test must perform a leak check on the gas cap and provide a unique test result.

(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) Fuel Inlet Pressure Test.

(i) Pressure Test Method. A vehicle shall fail the pressure test if the fuel vapor control system isolated between the fuel inlet and a clamp on the line between the fuel tank and the canister, (located as close to the canister as possible) loses more than 6 inches of water pressure over a period of 120 seconds starting from a stabilized pressure of 14±1 inch of water.

(ii) Fast-Pass. Fast-pass determinations for the pressure test may be made anytime during the pressure decay between 20 and 120 seconds if the measured pressure exceeds:

$$P_m = P_i - \left(\frac{0.33 * P_i + 1.33}{120}\right) * t$$

Where: P_m = Measured pressure in inches of water

P_i = Initial pressure in inches of water

t = Time in seconds

(d) Gas Cap Test Standards

The methods described below are applicable to pre OBD II evaporative emission controlled vehicles. OBD II vehicles equipped with evaporative control monitors and certified to the enhanced evaporative emission standards are being phased-in with the 1996 through 1998 model years. Procedures for OBD vehicles will be published in a separate document.

Pressure decay methods using a 1 liter head space are currently permitted under the June 1996 version of the IM240 technical guidance. As this method has been widely used in IM240 testing it will continue to be allowed. The pressure decay loss of 6 inches of WC from a starting pressure of 28 in. WC referenced to 70F and 1 atm and assuming a 1 liter head space, equates to a flow rate of about 80 cc/min.

(1) Visual Check. The vehicle shall fail the gas cap visual check if the cap is missing, obviously defective, or the wrong style cap for the vehicle. An example of a wrong style includes a cam lock cap installed on fill pipe which requires a threaded cap. States conducting cap testing should work with OEM suppliers to develop a user friendly method of identifying wrong style gas caps.

(2) Pressure Decay Test Standard. For pressure decay methods using a 1 liter head space and the June 1996 IM240 technical guidance, the fuel cap shall fail the pressure test if it loses more than 6 inches of water column (WC) pressure over a period of 10 seconds from a starting pressure of 28±1 inch WC.

(3) 60 cc/min Flow Standard. The gas cap leak rate may be determined by pressure loss measurement, direct flow measurement, or flow comparison methods and shall be compared to a pass/fail flow rate standard of 60 cubic centimeters per minute of air at 30 inches of water column. The flow rate methods shall be referenced to standard conditions of 70°F and 1 atm. If the leak rate exceeds 60 cc/min at a pressure of 30 inches of water column, the cap shall fail the test.

§85.2221 IM240 Test Procedures

(a) General Requirements

(1) Test Parameters. The following information shall be determined for the vehicle being tested and used to automatically select the dynamometer inertia, power absorption settings, and evaporative emission test parameters.

(i) Model Year
(ii) Manufacturer
(iii) Model name
(iv) Body style
(v) Number of cylinders
(vi) Engine displacement

Alternative computerized methods of selecting dynamometer test conditions, such as VIN decoding, may be used.

(2) Ambient Conditions. The ambient temperature, absolute humidity, and barometric pressure shall be recorded continuously during the transient test, or as a single set of readings if taken less than 4 minutes prior to 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 by the inspector, if necessary.

(2) Traction Control and Four-Wheel Drive (4WD). Vehicles with traction control systems that cannot be turned off shall not be tested on two wheel drive dynamometers. Vehicles with 4WD that cannot be turned off shall only be tested on 4WD dynamometers. If the 4WD function can be disabled, then 4WD vehicles may be tested on two wheel drive dynamometers.

(3) Leaks. The vehicle shall be inspected for exhaust leaks. Audio assessment while blocking exhaust flow, or measurement of carbon dioxide or other gases, shall be acceptable. Vehicles with leaking exhaust systems shall be rejected from testing.

(4) 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 well below (less than 180°F) normal operating temperature, the vehicle shall not be fast-failed 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.

(5) Tire Condition. Vehicles shall be rejected from testing if tire cords, bubbles, cuts, or other damage are visible. Vehicles shall be rejected that have space-saver spare tires, or unreasonably sized tires on the drive axle. 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. The tires of vehicles being tested for the purposes of program evaluation under §51.353(c) shall have their tires inflated to tire side wall pressure.

(6) 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 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 §85.2226(c)(4)(iv). 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 ppmC HC, 30 ppm CO, and 2 ppm NO_x, or outside ambient air levels (not influenced by station exhaust), whichever are greater.

Other methods that do not employ a fixed analysis time of 15 seconds may be used, if approved by the Administrator.

(7) Sample System Purge. While a lane is in operation, the CVS shall continuously purge the CVS hose between tests. The blower may be turned off if the CVS is not in operation, but the system shall be purged for 2 minutes prior to the start of a test if the blower has been turned off. The off time shall be computer monitored and recorded to a history file for quality assurance.

(c) Equipment Positioning and Settings

(1) 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.

(2) Cooling System. The use of a cooling system is optional when testing at temperatures below 50°F. Furthermore, the hood may be opened at the state's discretion. If a cooling system is in use, testing shall not begin until the 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.

(3) Vehicle Restraint. Testing shall not begin until the vehicle is restrained. Any restraint system shall meet the requirements of §85.2226(a)(5)(vii). The parking brake shall be set for front wheel drive vehicles prior to the start of the test. The parking brake need not be set for vehicles that release the parking brake automatically when the transmission is put in gear.

(4) Dynamometer Settings. Dynamometer power absorption and inertia weight settings shall be automatically chosen from an EPA-supplied electronic look-up table which will be referenced based upon the vehicle identification information obtained in 85.2221(a)(1). Vehicles not listed shall be tested using default power absorption and inertia settings in the latest version of the EPA I/M Look-up Table, as posted on EPA's web site: www.epa.gov/orcdizux/im.htm

(5) 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) Queuing Time. When the vehicle queue exceeds 20 minutes, a vehicle shall get a second-chance emission test if it fails the initial test and all criteria exhaust components are at or below 1.5 times the standard. At the state's discretion, second-chance testing may be granted if criteria exhaust components exceed any preset level above the standard.

(2) Program Evaluation. 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.

(i) Any vehicle may be preconditioned by maneuvering the vehicle on to the dynamometer and driving the 94 to 239 second segment of the transient cycle in 85.2221(e)(1). This method has been demonstrated to adequately precondition the vast majority of vehicles (SAE 962091).

Other preconditioning cycles may be developed and used if approved by the Administrator.

(ii) Alternatively, modal analysis of the failing second-by-second test data may be performed to identify vehicles that would benefit from additional pre-conditioning. Appendix F provides retest criteria developed by Sierra Research under EPA contract 68-C4-0056 Work Assignment 2-04.

(e) Vehicle Emission Test Sequence

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

Time second	Speed mph	Time second	Speed mph	Time second	Speed mph	Time second	Speed mph	Time second	Speed mph
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, or 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 while disregarding shifts above the highest gear.

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

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

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

(iii) Speed Variations. 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) Underpowered Vehicles. 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. If the vehicle is underpowered and unable to adequately follow the trace, it may at the State's discretion be rejected from testing or given an idle test.

(v) Exceedances. Exceedances of the limits in §85.2221(5)(ii) through §85.2221(5)(iii) shall automatically result in a void test. The station manager can override the automatic void of a test if the manager determines that the conditions specified in §85.2221(e)(4)(iv) occurred.

(5) Speed Variation Limits.

(i) Limits. Based on work performed under contract 68-C4-0056, Work Assignment 2-04 the following Positive Kinetic Energy limits were developed by Sierra Research. These results are based on an analysis of 16,581 IM240 tests conducted in AZ.

(ii) PKE =

$$PKE = \frac{\sum_{t=0}^{t} PP_t}{\int_{x=0}^{x} dx}$$

where: $PP_t = V^2_t - V^2_{(t-1)}$ mi^2/hr^2 for $V_t > V_{(t-1)}$

$PP_t = 0$ for $V_t = V_{(t-1)}$

$x =$ distance (mi)

(iii) PKE Limits. Full Test PKE Limits:

Upper Limit 3456 mi/hr^2

Lower Limit 3082 mi/hr^2

NOTE: The test cycle shall be invalid for a pass/fail determination if the PKE value is below the lower limit for a passing vehicle or above the upper limit for a failing vehicle. PKE values alone should not be used to make an early pass/fail determination.

Test cycles with PKE values outside the lower and upper limits shall be valid for preconditioning provided that all other requirements are met.

(iv) Second-by-Second Limits. Second-by-Second PKE upper and lower limits are listed in Appendix G.

(6) Distance Criteria. The actual distance traveled for the transient driving 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 void the test and result in a new test. More than 3 stalls shall result in rejecting the vehicle from testing.

(8) Inertia Weight Selection. The inertia weight selected for the vehicle shall be verified as specified in §85.2226(a)(1)(i). 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.

(9) 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.

(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).

§85.2222 Evaporative System Pressure and Gas Cap Test Procedures

(a) General Requirements

(1) Pressure Test. The on-vehicle pressure tests described in §85.2222(c) shall be performed after any tailpipe emission test. Vehicles receiving a pressure test specified in §85.2222(c) should also be given a gas cap leak test specified in §§85.2222(d).

(2) Controlling Test Variability. 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. Volume compensation for the pressure test is not required, but the vapor space volume will affect the pressure decay measurement. Excessive fuel vapor pressure, although not controllable at the time of test, may affect the accuracy and repeatability of the result.

(3) Gas Cap Test Requirement. A gas cap test described in §85.2222(d) may be performed before or after the tailpipe emission test.

(4) Alternative Techniques. Alternative gas cap or pressure test procedures may be used if they are shown to be equivalent or better than those described below.

(b) Pre-inspection and Preparation

(1) Visual Inspection - Canister. 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) Visual Inspection - System. 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) Visual Inspection - Gas Cap. If the gas cap is missing, obviously defective, or the wrong style cap for the vehicle, the vehicle shall fail the visual inspection.

(c) Fuel Inlet Pressure Test

(1) Equipment Set-up. The vapor vent line(s) from the gas tank to the canister(s) shall be clamped off as close to the canister(s) as practical without damaging evaporative system hardware. 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. The proper adapter, as specified in §85.2227(c)(2)(i) shall be selected.

(2) Starting Pressure. The gas tank shall be pressurized to 14±1 inch of WC, or a vehicle specific pressure as identified in the I/M Look-up Table.

(3) Stability. Pressure stability shall be monitored for a period of 10 seconds prior to the start of the pressure decay measurement. One definition of stability is a loss of no more than 5 inches WC over a 10 second period when the initial pressure is 14±1 inch WC. If the loss of pressure in 10 seconds exceeds this value, two more attempts shall be made to reach stability. Failure to achieve stability likely indicates the presence of a large leak and therefore failure of the pressure test. Alternate definitions of stability may be proposed by the State and approved by the Administrator. Stability criteria for flow comparator or direct flow measurement methods do not apply.

(4) Volume Compensation. Pressure decay measurements are affected by the vapor volume in the fuel tank. Volume-compensated pressure decay measurements are presently not required. By design, flow comparator or flow measurement methods do not require volume corrections.

(5) Pressure Monitoring. Close the pressure source and measure the loss in pressure over a 120 second interval. Fast-pass determinations may be made using the equations in §85.2205(d)(2)(ii).

(6) Clamp Removal. Remove the clamp on the vapor line and carefully relieve pressure and remove the adapter used to supply pressure to the vapor space.

(d) Gas Cap Test

(1) Cap Installation. The fuel cap, or caps, shall be removed from the fuel inlet(s) and installed on a portable or bench test rig using the adapter appropriate for the gas cap as specified in §85.2227(d)(1)(ii).

(2) Leak Measurement. The gas cap leak rate shall be measured and compared against a 60 cc/min at 30 in. WC flow standard. Pressure decay measurement using instruments with a 1 liter head space shall be made from an initial pressure of 28 in. WC and be compared against a loss of 6 in. WC in 10 seconds.

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

§85.2226 IM240 Equipment Specifications

(a) Dynamometer Specifications

(1) General Requirements.

(i) Capacity. 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) Test Parameters. Road load horsepower and inertia simulation shall be automatically selected from the EPA I/M Look-up Table, or equivalent data base, based on the vehicle parameters in the test record.

(iii) Alternative Designs. Alternative dynamometer specifications, designs, and error checking methods may be used if the alternative provides proper dynamometer loading over the IM240 driving cycle.

(iv) Units. Specifications in this section are generally expressed in units of horsepower. System designs using equivalent units of force, English or SI, are permissible.

(v) Ambient Range. The dynamometer shall be designed to meet specifications at an ambient temperature range of 35 to 110°F, and at absolute humidity values representative of the IM240 testing location.

(2) Power Absorption.

(i) Power Absorber Design. The power absorber unit shall be an electric AC or DC motor/absorber design. Eddy current designs may be approved if proven equivalent to other designs in terms of inertia response time, total load, and emissions performance over an IM240 driving cycle.

(ii) Range.

(A) Mechanical Inertia Dynamometers. Dynamometers using clutchable flywheels shall have sufficient power absorber capacity to accommodate the TRLHP values in the EPA I/M Look-up Table.

(B) Electric Inertia Dynamometers. Dynamometers using a combination of mechanical base inertia and supplemental electrical inertia shall have sufficient power absorber capacity to accommodate the sum of the TRLHP values in the EPA I/M Look-up Table plus the power absorbed from accelerating a vehicle at 3.3 mph/sec at the equivalent test weight (ETW) specified in the I/M Look-up Table.

(iii) Accuracy. The power absorber shall be adjustable across the required horsepower range at 50 mph in 0.1 horsepower increments. The accuracy of the power absorber or power exchange unit, for road load simulation only, shall be ±0.25 horsepower or ±3% of point, whichever is greater.

(iv) Indicated Horsepower. At constant velocity, the power absorber shall load the vehicle according the following equations:

IHP = TRLHP - PLHP - GTRL

Where: IHP is the dynamometer indicated, or set, horsepower.

TRLHP is the track, or total, horsepower for a particular vehicle.

PLHP is the dynamometer parasitic loss horsepower.

GTRL is the generic tire/roll loss of a vehicle on the dynamometer.

TRLHP, PLHP, GTRL, and therefore IHP, are all expressed as three term polynomials of the type:

$$HP = A*Obmph + B*Obmph^2 + C*Obmph^3$$

Where: HP represents individual expressions relating IHP, TRLHP, PLHP, or GTRL as a function of velocity.

A, B, or C represent horsepower coefficients for the individual expressions relating IHP, TRLHP, PLHP, or GTRL as a function of velocity.

Obmph is the velocity in miles per hour.

Expressions for TRLHP, and GTRL are found in Appendices H and I.

(3) Inertia.

(i) Range. The dynamometer shall provide inertia simulation capability of 2000 to 5500 pounds for light duty vehicles and trucks less than or equal to 5500 pounds ETW. Dynamometers used for testing light duty vehicles and trucks over 5500 ETW shall have inertia simulation capability to set the inertia at the correct value as referenced in the EPA I/M Look-up Table.

(ii) Mechanical Inertia Simulation. The dynamometer shall be equipped with clutchable mechanical flywheels with inertia selectable to a 250 pound sensitivity. The tolerance on the base inertia weight and the flywheels shall be within 1% of the specified test weights. The test system shall be equipped with a method, independent from the flywheel selection system, that identifies which flywheels are actually rotating during the transient driving cycle.

(iii) 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.

(A) System Response. The torque response to a step change shall be at least 90% of the command value within 200 milliseconds, 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. Response time measurements shall be performed at 2000, base inertia, and 5500 pounds of inertia.

(B) Simulation Error. An inertia simulation error (ISE) shall be continuously calculated any time the actual dynamometer speed is between 10 and 60 mph. The average positive ISE over the driving cycle shall be calculated by the equation in §85.2226(a)(3)(iii)(C), and shall not exceed 2 percent of the inertia weight selected (IW_S) for the vehicle under test.

(C) $$ISE = \left(\frac{IW_s - I_t}{IW_s}\right) * 100$$

Where: ISE = Inertia simulation error expressed in percent.

IW_s = Total inertia desired, or selected, in pounds mass.

I_t = Total inertia being simulated by the dynamometer in pounds mass.

(D) $$I_t = I_m + \frac{32.2}{V}\int_{t=0}^{t}(F_m - F_{rl})dt$$

Where: I_t = Total inertia being simulated by the dynamometer in pounds mass.

I_m = Base mechanical inertia of the dynamometer in pounds mass.

32.2 = Gravitational constant, (ft)(lbm)/(lbf)(sec^2).

V = Measured roll speed in feet/second.

F_m = Force measured by the load cell converted to force at the roll surface in pounds.

F_{rl} = Dynamometer road load expressed as a three term polynomial in pounds force at the measured roll speed.

t = Time in seconds.

(4) Dynamometer Parasitic Loss

(i) Friction Curves. The dynamometer internal friction curves, typically bearing and windage friction expressed as a function of velocity, shall be capable of being automatically measured, stored, and accurately accounted for over the IM240 driving cycle.

(ii) Friction Curve Definition. Parasitic loss friction shall be expressed in a tabular format as a function of velocity, or as a polynomial of the type:

$$PLHP = A_p*Obmph + B_pObmph^2 + C_pObmph^3$$

Where: PLHP represents the dynamometer parasitic friction, expressed in horsepower.

A_p, B_p, and C_p are coefficients relating a least squares fit of dynamometer friction and velocity.

Obmph is dynamometer roll surface velocity in miles per hour.

(5) 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)(5)(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 Installation. Rolls shall be installed in the floor such that vehicles will be within ±5 degrees of horizontal.

(iii) Roll Spacing. The spacing between the roll centers shall comply with the following equation to within +0.5 inches and -0.25 inches.

$$\text{Roll Spacing} = (24.375 + D) * \sin 31.5^\circ$$

Where: Roll Spacing is the distance between the roll centerlines in inches.

D = Roll diameter in inches

(iv) Roll Surface. The surface finish and hardness shall be such that tire slippage is minimized when testing vehicles using the inertia weight and horsepower settings found in the EPA I/M Look-up Table while following the IM240 driving schedule, and that tire wear and noise are minimized. Knurled roll surfaces are acceptable.

(v) 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 over the IM240 driving schedule.

(vi) Vehicle Lift. A vehicle lift system located between the dynamometer rolls shall be provided to facilitate drive axle positioning and vehicle egress from the dynamometer.

(vii) Vehicle Restraint System. The dynamometer shall include a system of safely restraining the forward and side-to-side motion of front wheel drive vehicles, and the forward motion of rear wheel drive vehicles during the IM240 driving schedule, while allowing unobstructed ingress and egress from the dynamometer.

(6) Load Cell.

(i) Torque Measurement. The dynamometer shall have a torque measurement system accurate to within ±2% of full scale.

(ii) Dead Weights. Dead weights used to calibrate a torque meter or load cell shall be traceable to NIST and be accurate to within ±0.5%.

(iii) Dynamic Calibrations. Designs using an F = MA method for calibrating the load cell are also acceptable.

(7) Driver's Aid.

(i) Video Display. The dynamometer shall be equipped with a video display device able to be easily positioned to accommodate all test vehicles while clearly visible to the driver. The display shall have a method that allows the driver to accurately and smoothly follow the desired driving cycle.

(ii) Remote Capabilities. The dynamometer shall have a means of allowing the driver to start the test, perform an emergency stop, and perform other necessary and convenient functions related to the test while inside the vehicle.

(8) Other.

(i) Augmented Braking. Augmented braking shall be used during vehicle decelerations on the driving cycle. Augmented braking shall be actuated only when the negative force applied by the vehicle at the roll surface is greater than 110 pounds. If the augmented braking is not linked to driver braking, the driver shall be signaled to not accelerate during this period.

(ii) Cooling Fan. The cooling fan capacity shall be 5400 ±300 SCFM, positioned within 12 inches of the intake to the vehicle's cooling system, and avoid unrepresentative cooling of the engine and exhaust control system.

(9) All Wheel Drive Dynamometers.

(i) Design. The dynamometer shall meet the requirements for two wheel drive vehicles and be capable of testing traction control and all wheel drive vehicles in a safe manner without damaging the vehicle.

(ii) Wheelbase. The all wheel drive dynamometer shall be capable of testing vehicles having a wheelbase between 84 and 125 inches, or as necessary to meet the wheelbase values in the I/M Look-up Table. The system shall provide a locking mechanism to secure the roll at the desired wheelbase.

(iii) Speed Synchronization. Front and rear wheels shall maintain speed synchronization within ±0.1 mph.

(b) Constant Volume Sampler

(1) General Design Requirements.

(i) Venturi Type. A constant volume sampling (CVS) system of the critical flow venturi (CFV) or the sub-sonic venturi (SSV) 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 700 SCFM system is assumed to satisfy this requirement. The range of ambient conditions may require the use of heated sample lines. Should heated sample lines be used , the lines and components shall be heated to a minimum of 120°F and a maximum of 250°F, which shall be monitored during the 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 Designs. Alternative CVS specifications, materials, or designs may be allowed upon a determination by the Administrator, 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, as measured at the tailpipe, 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 §86.109-90.

(c) Analytical Instruments

(1) General Requirements.

(i) Instrument Specifications. 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 lane environment.

(ii) Alternative Designs. Alternative analytic equipment specifications, materials, designs, or detection methods may be allowed upon a determination by the Administrator, 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 700 SCFM CVS is used, the analyzer calibration curve shall cover at least the range of 0 ppmC to 2,000 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. The calibration curve must comply with the quality control specifications in §85.2234(d) for calibration curve generation.

(ii) Carbon Monoxide Analysis. CO analysis shall be determined using a non-dispersive infrared analyzer. If a 700 SCFM CVS is used, CO analysis shall cover at least the range of 0 ppm to 10,000 ppm (1%). In order to meet the calibration curve requirements, two CO analyzers may be required - one from 0 to 1000 or 2000 ppm, and one from 0 to 1% CO. Use of a different CVS flow capacity shall require an adjustment to these ranges. Appropriate documentation supporting any adjustment in ranges shall be available. The calibration curve requirements and the quality control specifications in §85.2234(d) apply to both analyzers.

(iii) Carbon Dioxide Analysis. CO_2 analysis shall be determined using an NDIR analyzer. If a 700 SCFM CVS is used, CO_2 analysis shall cover at least the range of 0 ppm to 40,000 ppm (4%). Use of a different CVS flow capacity shall require an adjustment to these ranges. Appropriate documentation supporting any adjustment in ranges shall be available. The calibration curve must comply with the quality control specifications in §85.2234(d) for calibration curve generation.

(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. Alternatively, NO_x measurements may be made by re-calibrating the chemiluminescence analyzer in NO only mode, then running the analyzer in NO only mode and multiplying the result by 1.03. This will eliminate the need for the converter and flow balance checks in §85.2234(d)(5) and §85.2234(d)(6).

If a 700 SCFM CVS is used, the NOx analysis shall cover at least the range of 0 ppm to 500 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. The calibration curve must comply with the quality control specifications in §85.2234(d) for calibration curve generation.

(3) System Response Requirements. 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 shall be less than 10 seconds.

(4) Integration Requirements.

(i) Sampling Frequency. 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) Time Alignment. The system shall properly time correlate each analyzer signal and the CVS signals to the driving trace.

(iii) Engineering Units. 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) Multiple Analyzers. 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) Background Samples. For all constituents, the background concentration levels from the lowest range 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) 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.

(iii) 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.

§85.2227 Evaporative System Equipment Specifications

(a) General Requirements

(1) Equipment Design. Automated and computerized test systems shall be used for the evaporative system tests wherever they are appropriate. 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, pressure, or gas cap test equipment specifications or designs may be proposed by a State if they are supported by data and approved in advance by the Administrator.

(b) Evaporative System Pressure Test Equipment

(1) General Requirements.

(i) Alternative Designs. Flow measurement or flow comparator leak detection methods are acceptable if supported by data and approved in advance by the Administrator. Standards for flow based methods have not been established.

(ii) Pressurizing Gas. Nitrogen, or an equivalent non-toxic, non-greenhouse, inert gas, shall be used for pressurizing the evaporative system. Air should only be used if the pressurized vapor space is outside the combustible limits for the vehicle fuel type.

(iii) Automatic Operation. The process for filling the vapor space, 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 specified 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.

(iv) 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.

(v) Grounding. A fillpipe pressure test must be designed to prevent electrostatic discharge that would pose a flammability risk during the test.

(2) Adapters and Clamps.

(i) Fuel Inlet Adapters. Adapters attached to the fuel fillpipe inlet shall be used to supply pressurized gas into the fuel tank. 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 covered by the program.

(ii) Hose Clamp. The hose clamp used for the fuel inlet pressure test shall be designed to apply only enough pressure to close the flexible vent line between the fuel tank and canister without damaging it. The nose of the clamp shall be smooth-surfaced or otherwise designed to avoid damage to the vent line.

(3) Pressure Gauge. The device for measuring pressure shall have a minimum range of 0 to 28 inches of water and an accuracy of $\pm$0.3 inches of water, or 2% of point, whichever is greater.

(c) Gas Cap Test Equipment

(1) General Requirements.

(i) Alternative Designs. Leak testers failing gas caps with a test standard below 60 cc/min at 30 in. WC are permissible provided they do not falsely fail gas caps designed to meet vehicle manufacturer OEM specifications, are repeatable and accurate in a centralized I/M environment, and demonstrate quantifiable reductions in real world mass emissions. OEM leak rates for individual manufacturers are proprietary. Information submitted to EPA shows some vehicle manufacturers had maximum leak rates up to 20 cc/min at 30 inches of WC.

(ii) Gas Cap Adapters. The gas cap tester shall accommodate at least 95 percent of the gas caps that are used on U.S. light duty vehicles and trucks for the model years covered by the gas cap test program.

(iii) Pressurizing Gas. Air, Nitrogen, or an equivalent non-toxic, non-greenhouse, inert gas, shall be used for pressurizing the gas cap tester.

(iv) Automatic Operation. The process for making a pass/fail decision shall be automated. The gas cap tester shall provide for automated pass/fail determination and automated transfer of the pass/fail result to a host computer, i.e. a real-time data link.

(v) Over-Pressurization. The tester shall control the supply pressure of the gas used for pressure decay, direct flow measurement, or flow comparison methods and prevent over-pressurization.

(2) Gas Cap Tester. Gas cap testers employing internal reference orifices, or pressure measurement devices, shall be traceable to NIST flow or pressure measurement standards.

(i) Range. The tester shall identify passing gas caps with a leak rate equal to or less than 60 cc/min of air at 30 inches of WC, and failing caps with leak rates more than 60 cc/min at 30 inches of WC at reference conditions of 70F and 1 atm.

(ii) Filter. A serviceable air filter shall be incorporated upstream of flow orifices.

(iii) Power Supply. Battery powered testers shall be equipped with an automatic shutoff and a low-battery indicator.

(iv) Accuracy. Pressure decay, direct flow measurement, or flow comparison methods shall be accurate to ±3 cc/min at the 60 cc/min flow standard.

(v) Reference Caps and Orifices. NIST traceable reference passing fuel caps or orifices of nominal 52-56 cc/min, and NIST traceable reference failing fuel caps or orifices of nominal 64-68 cc/min shall be supplied with the tester for daily verification tests.

(vi) Head Space. Pressure decay methods shall employ a head space sized to produce correct results at the 60 cc/min at 30 in. WC standard.

§85.2234 IM240 Test Quality Control Requirements

(a) General Requirements

(1) Manufacturers' Recommendations. Manufacturers' recommendations for equipment installation, calibration, and maintenance, shall be followed.

(2) Statistical Process Control. SPC tracking methods shall be established for appropriate equipment checks and custom diagnostic or verification tests.

(3) Modifications to Quality Control Requirements. Changes to the type or frequency of the quality checks are permitted provided they are based on SPC analysis, or data from experimental studies.

(b) Dynamometer

(1) Dynamometer Manufacturer Recommendations

(i) Minimum Requirements. The dynamometer manufacturer's requirements for periodic diagnostic checks, calibration, scheduled maintenance, and recommended quality control monitoring shall be followed.

(ii) Warm-up Requirements. The dynamometer manufacturer's procedure for insuring proper warm-up over a 35 to 110°F temperature range shall be followed.

(2) Coast Down Testing

(i) Frequency. Dynamometers with electric and mechanical inertia simulation shall receive a daily unloaded (vehicle off the dynamometer) coast down check over the range of 60 to 10 mph. This daily check shall be run at alternating combinations of inertia and road load settings. Dynamometers using only mechanical flywheels for inertia simulation shall also receive additional weekly coast down checks to properly characterize the friction at other combinations of flywheel weights. The number of these coast downs shall be established based on the dynamometer design and quality control monitoring.

(ii) Load Settings. Inertia and power absorber settings shall be representative of vehicle test conditions, and shall result in nominal coast down times of 15-20 seconds when time is measured between 55 and 45 mph, and 22-33 seconds when time is measured between 22 and 18 mph. Inertia settings for clutchable flywheel dynamometers are discretionary but should attempt to be above and below the base inertia of the dynamometer and represent high and low inertia weight vehicles.

(iii) Quality Control Limits. Actual control limits for the coast down tests shall be established by statistical process control practices. The 55 to 45 mph and 22 to 18 mph coastdown times shall be within ±1 second, and ± 6 seconds, respectively, of the theoretical coast down times. These ±1 and ±6 second limits are based on the 15-20 and 22-33 second coastdown times in the preceding paragraph. Theoretical coastdown time is based on the following equation:

$$t = \frac{\left(0.5 * ETW / 32.2\right) * (V_I^2 - V_F^2)}{550 * HP}$$

Where: t = The coastdown time in seconds

ETW = The Equivalent Test Weight in pounds

V_I = The initial roll velocity in feet/second

V_F = The final roll velocity in feet/second

IHP = The dynamometer indicated horsepower

An alternative to the ±1 or ±6 second limits is to perform an unloaded coastdown from 60 to 10 mph and reduce the speed/time data to produce a polynomial relationship between horsepower (or force) versus time. The measured horsepower curve shall be within ±0.25 horsepower or ±3% of point, whichever is greatest.

Dynamometers which exceed specific SPC limits or the coast down limits presented above, shall be removed from service until corrective action is taken to assure the dynamometer is performing satisfactorily.

(3) Parasitic Loss Checks

(i) Frequency. Checks of the parasitic loss curve shall be conducted at a frequency recommended by the dynamometer manufacturer, as required by inspection of quality control data, or as necessary following service to the dynamometer.

(ii) Quality Control Limits. Parasitic loss measurements shall be measured between 10 and 60 mph. Identification of outlier data shall be established by examination of quality control data.

Dynamometers which exceed dynamometer specific SPC limits for parasitic loss checks shall be removed from service until corrective action is taken to ensure the dynamometer is performing satisfactorily.

(4) Roll Speed.

(i) Frequency. Weekly checks of the roll speed measurement system shall be made, or at intervals recommended by the dynamometer manufacturer, or as required by inspection of quality control data, or as necessary following service to the dynamometer.

(ii) Quality Control Limits. If roll speed checks are conducted, the measured roll speed shall agree to within ±0.1 mph of the calibration standard. Dynamometers which exceed the 0.1 mph limit shall be removed from service until corrective action is taken to ensure the dynamometer is performing satisfactorily.

(5) Acceptance Criteria

(i) General. Prior to dynamometer acceptance, the dynamometer shall demonstrate compliance with the design criteria for the load cell accuracy, power absorber curve accuracy, roll geometry, dynamometer simulation error, electric inertia response time, and parasitic loss measurement. These criteria are specified in §85.2226(a).

(ii) Base Inertia Verification. The base inertia of dynamometers shall be verified before dynamometer acceptance. The base inertia weight plus individual prime weights shall be verified for dynamometers which simulate inertia with mechanical flywheels. The specified base inertia shall agree with acceptance testing measurements within ±10 pounds.

(iii) Independent Speed and Distance Verification. An independent method of verifying dynamometer roll speed and distance measurement accuracy shall be performed before dynamometer acceptance to ensure compliance with the specifications in §85.2226(a)(5)(v).

(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. SPC tracer gas injection data may be used to verify CVS flow in lieu of the annual calibration requirement. This data shall be made available to EPA upon request. 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 day using a procedure equivalent to that in §86.119(c). Deviations greater than ±4% shall result in automatic lockout of official testing until corrected. At the State's discretion, the frequency of this may be reduced to weekly.

(3) Cleaning Flow Passages. The sample probe shall be checked at least once per month, and cleaned if necessary in order 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 is serviced.

(6) System Response Time Check. The response time of each analyzer shall be checked upon initial installation and after each repair or modification to the flow system that would reasonably be expected to affect the response time, and at least once per week. 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 quality control limits. 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.

(7) Mixing Tee Acceptance Test.

(i) Static Pressure Requirement. 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) Single Exhaust System. 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) Dual Exhaust System. 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) Initial Installation Calibration. 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) Complete Range Calibration. The calibration curve shall consider the entire range of the analyzer as one curve.

(iii) Calibration Point Spacing. When both a low range analyzer and a high range analyzer are used for a single gas (e.g., CO), the high range analyzer shall use at least 5 calibration points plus zero in the lower portion of the high range scale corresponding to approximately 100% of the full-scale value of the low range analyzer. For all analyzers, at least 5 calibration points shall be used to define the calibration curve above the 5 lower calibration points. The calibration zero gas shall be used to set the analyzer to zero.

Alternatively, gas dividers may be used to generate a 10-point calibration curve employing equally spaced points.

(iv) Calibration Curve Fits. The calibration curves generated shall be a polynomial of the best fit and no greater than 4th order, and shall fit the data within ±2.0% at each calibration point as specified in §86.120-90, §86.122-78, §86.123-78, and §86.124-78.

(v) Mid-scale Verification. Each curve shall be verified for each analyzer with a confirming calibration standard between 30-60% 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 3 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 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 ppmC HC, 1 ppm NO_x, 10 ppm CO, or 40 ppm CO_2, 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 initial adjustment of a change in the up-scale span point shall be ± 2% of point on the appropriate analyzer range. 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. Zero and span potentiometers on the analyzer may be used between calibrations to minimize software corrections; however, a zero and span check shall be performed after any adjustment of a potentiometer.

(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 may be up to 90% of full scale, and the mid-point concentration shall correspond to approximately 15% of full scale.

(5) Monthly NO_x Converter Checks. The converter efficiency of the NO_2 to NO converter shall be checked on a monthly basis. The check shall be equivalent to §86.123-78 (for reference see TSD Form 305-01) except that the concentration of the NO gas shall be in the range of 75-400 ppm. Alternative methods may be used if approved by the Administrator.

This check is not required if the measurements of NO only are being performed per 85.2226(c)(2)(iv) with the NOx analyzer run in NO only mode.

(6) Monthly NO/NO_x Flow Balance. The flow balance between the NO and NO_x test modes shall be checked monthly. The check may be combined with the NO_x converter check as illustrated in EPA NVFEL test laboratory Form 305-01.

This check is not required if the measurements of NO only are being performed per 85.2226(c)(2)(iv) with the NOx analyzer run in NO only mode.

(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) FID Optimization. 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) Methane Response. 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)(8)(iii). The frequency of this check may be reduced by providing 1 year of data for each analyzer that demonstrates less frequent checks are acceptable. If less frequent checks are used, the response check data shall be made available to EPA upon request.

(iii) Methane Response Definition. Ratio of Methane Response = FID response to CH_4 gas in ppmC /ppm CH_4 in the cylinder.

(9) Mid-Span or Cross-Checks. 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 used for these cross checks shall be a 1% NIST traceable mid-span bottle and the same bottle shall be used for all

analyzers at a given facility. The analyzer shall read this mid-span gas within 2.5% of the labeled value or the analyzer shall be taken out of service.

Alternatively, all gas bottles entering a facility shall be verified using a master bench and NIST traceable SRM, CRM, NTRM, or RGM gases. Quarterly checks would then be performed on each analyzer using three points at 25%, 50%, and 75% of full scale.

(10) Interference Test. The CO 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 CO instrument will be considered to be essentially free of CO_2 and water vapor interference if its response to a mixture of 3% CO_2 in N_2 which has been bubbled through water at 20°C produces an equivalent CO response, as measured on the most sensitive CO range, which is less than 1% of full scale.

(e) Gases

(1) General Requirements. Gas blends may contain up to three of any of the following components: HC, CO, CO_2, and NO. The HC component shall be propane. The diluent for blends containing HC shall be air. The diluent for blends containing NO shall be N_2. CO and CO_2 may be used with either air or N_2 as the diluent. Blends containing four interest components may be used only if approved by the Administrator. Blends containing NO_2 shall also require approval by the Administrator prior to use, except if used to perform the NO_x converter check specified in §85.2234(d)(5). Any interference effects between components in a gas blend shall be addressed in the quality control and quality assurance process. When a gas audit of the analytical system is performed, the auditor shall indicate whether CO_2 is present in the audit gas mixture prior to performing the audit.

(2) Calibration Gases. Gases used to generate and check calibration curves shall be traceable to a NIST SRM, CRM, NTRM, or RGM and have a stated uncertainty to within 1% of the standard by gas comparison methods. Calibration zero gas shall be used when using a gas divider to generate intermediary calibration gases.

(3) Span Gases. Gases used for up-scale span adjustment, cross-checks, and for mid-scale span checks shall be traceable to NIST SRM, CRM, NTRM, or RGM and have a stated uncertainty to within 2% of the standard by gas comparison methods. Span gas concentrations shall be verified immediately after a monthly calibration curve check and before being put into service. If the reading on the span gases exceeds 2.5% of the label value, the system or gases shall be taken out of service until corrective action is taken. When a gas divider is used to generate span gases, the diluent gas shall not have impurities any greater than the working zero gas.

(4) Calibration Zero Gas. The impurities in the calibration zero gas shall not exceed 0.1 ppmC, 0.5 ppm CO, 1 ppm CO_2, and 0.1 ppm NO. Calibration zero grade air shall be used for the FID zero calibration gas. Calibration zero grade nitrogen or calibration zero grade air shall be used for CO, CO_2, and NO_x zero calibration gases.

(5) Working Zero Gas. The impurities in working zero grade gases shall not exceed 1 ppmC, 2 ppm CO, 400 ppm CO_2, and 0.3 ppm NO_x. Working zero grade air or calibration zero grade air shall be used for the FID zero span gas. Working or calibration zero grade nitrogen or air shall be used for CO, CO_2, and NO_x zero span gases.

(6) FID Fuel. The fuel for the FID shall consist of a mixture of 40% ($\pm$2%) hydrogen, and the balance helium. The FID oxidizer shall be zero grade air, which can consist of artificial air containing 18 to 21 mole percent of oxygen.

(7) Gas Naming Protocol. Gases used for calibration or auditing shall be named according to a written established practice that has been approved by the Administrator. An accepted gas naming procedure for I/M test purposes is the IM240 Gas Certification Protocol dated 10/27/94, or its latest revision. Copies of the 10/27/94 document are available upon request from EPA.

(f) Overall System Performance

(1) Emission Levels. For each test lane, the average, median, 10th percentile and 90th percentile of the composite emissions (HC, CO, CO_2, and NO_x) measured shall be monitored on a monthly basis. Differences in the monthly average of greater than ±10% by any one lane from the facility-average or combined facility-average, or by any one facility from the combined facility-average shall require an investigation to determine whether the single lane or facility has a systematic equipment or operating error or difference. Where it can be determined that the averages from one facility (or facilities) are offset from the average of the other facilities based on the mix of vehicles tested, the ±10% limit shall be compared to the expected offset. If systematic equipment or operating errors or differences causing the offset are found, such errors shall be corrected. The sample period may be adjusted to assure that a reasonably random sample of vehicles was tested in each lane.

(2) Pass/Fail Status. The average number of passing vehicles and the average number of failing vehicles shall be monitored monthly for each test lane. Differences in the monthly average of greater than ±15% by any one lane from the facility-average or combined facility-average, or by any one facility from the combined facility-average shall require an investigation to determine whether the single lane or facility has a systematic equipment or operating error or difference. Where it can be determined that the averages from one facility (or facilities) are offset from the average of the other facilities based on the mix of vehicles tested, the ±15% limit shall be compared to the expected offset. If systematic equipment or operating errors or differences causing the offset are found, such errors shall be corrected. The sample period may be adjusted to assure that a reasonably random sample of vehicles was tested in each lane.

(g) Control Charts

(1) General Requirements. Control charts and Statistical Process Control theory shall be used to determine, forecast, and maintain performance of each test lane, each facility, and all facilities in a given network. The control charts shall cover the performance of key parameters in the test system. When key parameters approach control chart limits, close monitoring of such systems shall be initiated and corrective actions shall be taken when needed to prevent such systems from exceeding control chart limits. If any key parameter exceeds the control chart limits, corrective action shall be taken to bring the system into compliance. The control chart limits specified are those values listed for the test procedures, the equipment specifications, and the quality control specifications that cause a test to be voided or require equipment to be removed from service. These values are "fit for use" limits, unlike a strict interpretation of SPC control chart theory which may use tighter limits to define the process. The test facility is encouraged to apply SPC strict control chart theory to determine when equipment or processes could be improved. No action shall be required until the equipment or process exceeds the "fit for use limits" specified in this section.

(2) Control Charts for Individual Test Lanes. In general, control charts for individual test lanes shall include parameters that will allow the cause for abnormal performance of a test lane to be pinpointed to individual systems or components. Test lane control charts shall include at a minimum:

(i) Difference between theoretical and measured coast-down times

(ii) Difference between theoretical and measured CVS flow

(iii) Up-scale span change from last up-scale span (not required if software corrections are tracked)

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

(v) Difference between the analyzer response to the daily cross-check, and the test gas concentration

(vi) The system response time

(vii) FID CH_4 response ratio

(viii) Difference between theoretical or measured values for other parameters measured during quality assurance procedures

(3) Control Charts for Individual Facilities. Control charts for individual facilities shall consist of the test lane control charts for each test lane at the facility.

(4) Control Charts of Individual Inspectors. Control charts for individual inspectors shall include parameters that will allow the cause for abnormal performance to be evaluated, such as technician IM240 driving quality.

§85.2235 Evaporative Test Quality Control Requirements

(a) General Requirements

(1) Manufacturers' Recommendations. Manufacturers' recommendations for equipment installation, calibration, and maintenance shall be followed.

(2) Statistical Process Control. SPC tracking methods shall be established for appropriate equipment checks and custom diagnostic or verification tests.

(3) Modifications to Quality Control Requirements. Changes to the type or frequency of the quality checks are permitted provided they are based on SPC analysis, or data from experimental studies.

(b) Evaporative System Pressure Checks

(1) Daily Checks. The pressure check system shall be pressurized to 28±1 inch of WC and monitored for a loss of pressure. Pressure testing shall be stopped and corrective action shall be taken to repair the system if a loss of pressure of more than 0.4 inches of WC is observed over a 15 second period.

(2) Bi-Weekly Check. Pressure gauges or measurement devices shall be checked on a bi-weekly basis against a reference gauge or device equal to or better than the specified performance requirements. Deviations exceeding the specified accuracy shall require corrective action.

(c) Evaporative System Gas Cap Checks

(1) Gas Cap Tester.

(i) Daily Checks. The tester shall be verified daily by testing and correctly identifying passing and failing reference gas caps or flow orifices as specified in §85.2227(d)(2)(v). Reference caps and orifices shall be stored in a dirt and dust free manner to prevent clogging and changes in flow rates. Reference caps and orifices shall be stored at the same temperature as the cap tester to provide accurate flow reference.

(ii) Corrective Action. Gas cap testing shall be stopped and corrective action taken to repair the tester if passing and failing reference gas caps or flow orifices cannot be correctly identified.

(iii) Reference Caps or Orifices - Flow Checks. Independent flow bench verification of the reference gas caps and flow orifices shall be conducted before initial usage, and at six month intervals, or as recommended by the cap tester manufacturer or as suggested by analysis of quality control data. The bench flow verification results shall be traceable to NIST.

(iv) Comparator Orifices - Flow Checks. Internal flow standard orifices for direct flow measurement methods, or flow comparator methods, shall be traceable to a NIST reference.

(2) Gas Cap Adapters.

(i) Leak Checks. The gas cap adapters shall be checked for visual damage daily and leak checked weekly, or by following the recommendations of the gas cap adapters supplier.

§85.2239 Test Report

(a) General Test Report Information

(1) Vehicle Description.

(i) License plate number
(ii) Vehicle identification number
(iii) Weight class
(iv) Odometer reading

(2) Date and Time. Date and end time of the tailpipe emission measurement test.

(3) Identification Information. Name or identification number of the individual performing the test and the location of the test station and lane.

(4) Warranty Provisions. For failed vehicles, a statement indicating the availability of warranty coverage as provided in Section 207 of the Clean Air Act.

(5) Certification. A statement certifying that the short tests were performed in accordance with applicable regulations.

(b) Tests and Results

(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). For the IM240 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) IM240 Scores. The reported score for the IM240 shall be in units of grams per mile and shall be selected based upon the following:

(i) Passing Scores - Composite IM240. If the emissions of any exhaust component on the composite IM240 are below the applicable standard in §85.2205(a), then the vehicle shall pass for that constituent and the composite score shall be reported.

(ii) Passing Scores - Phase 2. If the emissions of any exhaust component on the composite IM240 exceed the applicable standard in §85.2205(a) but are below the Phase 2 standard, then the vehicle shall pass for that component and the Phase 2 score shall be reported.

(iii) Failing Scores. If the emissions of any exhaust component on the composite IM240 exceed the applicable standard in §85.2205(a)(2) through §85.2205(a)(4) and exceed the Two Ways to Pass Standard as described in §85.2205(a)(1), then the vehicle shall fail for that component and the composite score shall be reported.

(iv) Emission Reporting. If a passing decision is made for all three exhaust components on the IM240 before the end of the full driving cycle according to the criteria described in §85.2205(a)(4), the passing results and reported emissions levels shall be those obtained at the time the test is terminated. Emission levels for the IM240 shall be reported in grams per mile calculated using the full IM240 mileage (not actual mileage). The emission standards reported shall be the composite standards (i.e., not the fast-pass standards).

(4) Pressure Test Scores. The score(s) for the pressure test(s) shall be reported as a change in pressure expressed in inches of water.

(5) Test Results. The test report shall indicate the pass/fail result for each test performed and the overall result. In the case of exhaust emission tests, the report shall indicate the pass/fail status for each component for which standards apply.

(6) Second-by-Second Measurements. For vehicles failing the IM240, a graph showing the second-by-second emission levels (see following example), for each exhaust component in grams per mile equivalent. The plots of HC, CO, NOx, and CO2 are expressed in units of "gram per mile equivalent," or:

Y = (X)*(239 seconds)/(1.959 miles)

Where: Y = Grams per mile equivalent calculated on a second by second basis

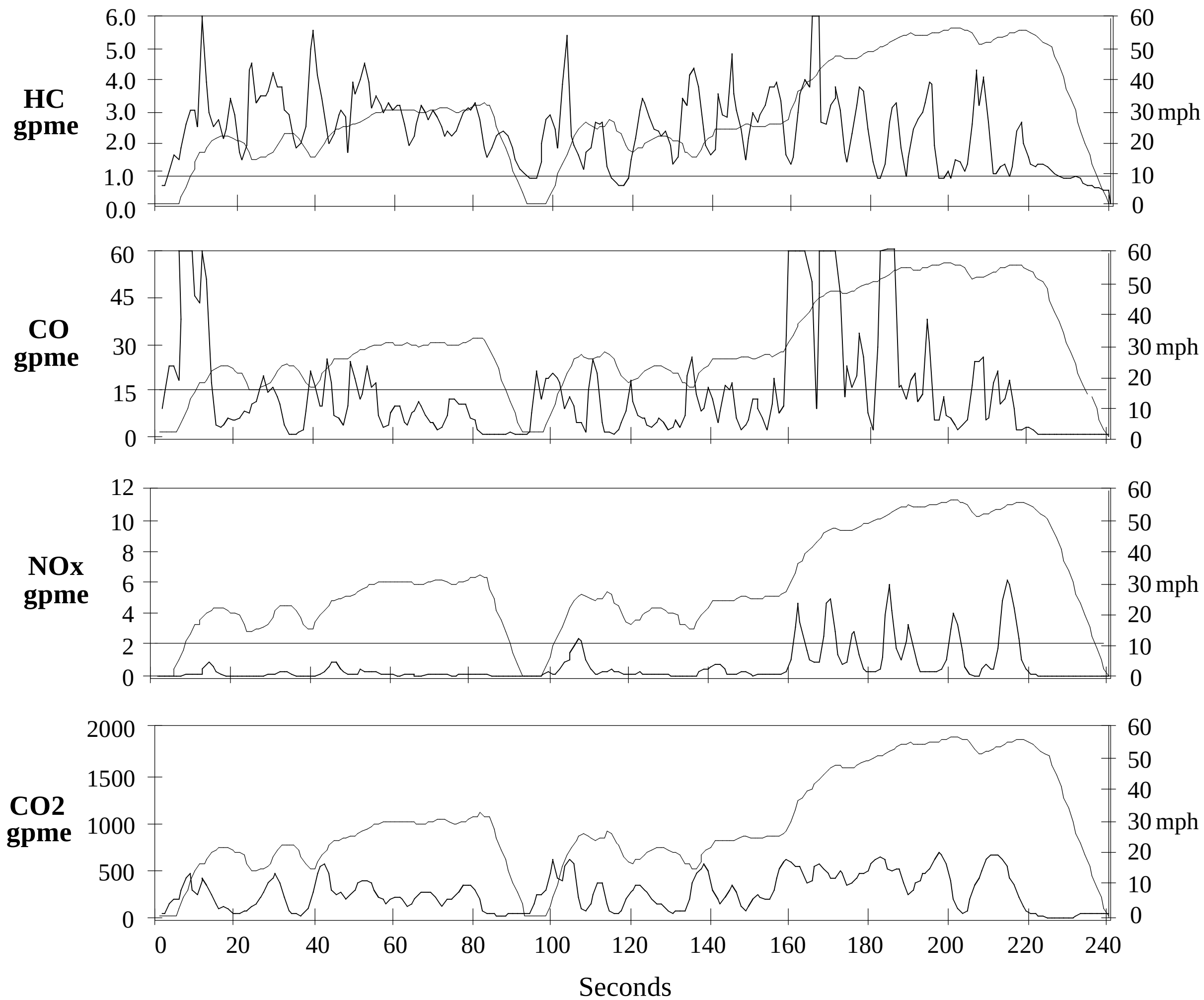
X = Grams of HC, CO, NOx, or CO2 calculated during the one second interval

(c) Recommended IM240 Second-By-Second Emissions Report

Test Number 4719

				Emission	Actual	Cut point
Model Year	1988	Test Weight	3000			
Make	XXXX	TRLHP	14.7	HC (gpm)	2.45	0.80
Model	YYYY	Traction Control	No	CO (gpm)	23.1	15.0
Cylinders	4	ABS	No	NOx (gpm)	0.71	2.00
Transmission	Auto	Gas Cap Test	Yes	CO2 (gpm)	279	n/a
Vehicle Type	LDGV	Press Test	Yes			

The following figures provide illustrations of the recommended second-by-second emissions output.


HC gpme
6.0
5.0
4.0
3.0
2.0
1.0
0.0
CO gpme
60
45
30
15
0
NOx gpme
12
10
8
6
4
2
0
CO2 gpme
2000
1500
1000
500
0
60
50
40
30 mph
20
10
0
0
20
40
60
80
100
120
140
160
180
200
220
240
Seconds

§85.2241 Terms

(1)	ALVW:	Adjusted Loaded Vehicle Weight: (VCW + GVWR)/2
(2)	CFV:	Critical Flow Venturi
(3)	CH_4:	Methane
(4)	CO_2:	Carbon dioxide
(5)	CO:	Carbon monoxide
(6)	CRM:	Certified Reference Material
(7)	CVS:	Constant Volume Sampler
(8)	ETW:	Equivalent Test Weight
(9)	FID:	Flame Ionization Detector
(10)	gpm:	Grams per mile
(11)	GVWR:	Gross Vehicle Weight Rating
(12)	HC:	Hydrocarbons
(13)	HDGT:	Heavy-Duty Gasoline-powered Truck greater than 8500 pounds GVWR
(14)	hp:	Horsepower
(15)	Hz:	Cycles per Second (Hertz)
(16)	I/M:	Inspection and Maintenance
(17)	IW:	Inertia Weight
(18)	LDGV:	Light-Duty Gasoline-powered Vehicle
(19)	LVW:	Loaded Vehicle Weight: VCW + 300 pounds
(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)	NO_x:	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
(35)	SCFM:	Standard cubic feet per minute
(36)	SPC:	Statistical Process Control
(37)	SRM:	Standard Reference Material
(38)	SSV:	Subsonic venturi
(39)	TRLHP:	Track Road-Load Horsepower
(40)	VCW:	Vehicle Curb Weight: Actual vehicle weight with standard equipment and 100% fuel fill
(41)	WC:	Pressure in inches of water column

Appendix A

Guidance on the Use of Fast-Pass IM240 Standards

Guidance on the Use of Fast-Pass IM240 Standards

A fast-pass decision is made by measuring the vehicle's cumulative emissions of each pollutant in each second, and comparing them to cumulative emission fast-pass standards for each pollutant for the second of the test under consideration. In general, if the vehicle's cumulative emissions are below a given level for all pollutants the vehicle passes. Testing continues until decisions are made for each pollutant. Measurements of all constituents shall continue to be taken as long as the test continues, including those constituents for which a decision has already been made.

These fast-pass standards are derived from an Arizona IM240 data set which included 3,718 tests. Fast-pass standards for each second represent the tenth lowest cumulative emission levels in that second obtained for vehicles failing the IM240 using the two-ways-to-pass criteria. Hence, vehicles that fall below this level are showing lower cumulative emissions at that point in the test than the cleanest vehicles failing the full test and therefore pass. Fast-pass determinations begin at second 30 of the IM240 cycle.

Beginning at second 109, fast pass decisions for HC and CO are based upon analysis of cumulative emissions in phase 2, the portion of the test beginning at second 94, as well as emission levels accumulated from the beginning of the test (the "composite" test). Fast-pass standards are derived for phase 2 of the test as described above. Since the phase 2 standards for NO_x are the same as the composite, the phase 2 NO_x fast-pass standards are also the same as the composite.

Scores

HC_t = cumulative composite HC at time = t seconds

CO_t = cumulative composite CO at time = t seconds
NOx_t = cumulative composite NOx at time = t seconds
HC_{bt} = cumulative Phase 2 HC at time = t seconds
CO_{bt} = cumulative Phase 2 CO at time = t seconds
NOx_{bt} = cumulative Phase 2 NOx at time = t seconds
Cumulative composite scores represent the cumulative grams of emissions from t = 0 seconds
Cumulative Phase 2 scores represent the cumulative grams of emissions from t = 109 seconds

Fast-Pass Standards

HC_{pt} = composite HC fast-pass standard at time = t seconds
CO_{pt} = composite CO fast-pass standard at time = t seconds
NOx_{pt} = composite NOx fast-pass standard for failing vehicles at time = t seconds
HC_{pbt} = Phase 2 HC fast-pass standard at time = t seconds
CO_{pbt} = Phase 2 CO fast-pass standard at time = t seconds
NOx_{pbt} = Phase 2 NOx fast-pass standard at time = t seconds

Fast-Pass Conditions

For $t > 30$ seconds, the vehicle shall pass if:

$HC_t < HC_{pt}$ and $CO_t < CO_{pt}$, $NOx_t < NOx_{pt}$;

additionally, for $t > 109$ seconds, the vehicle shall pass if:

$HC_{bt} < HC_{pbt}$ and $CO_{bt} < CO_{pbt}$ and $NOx_{bt} < NOx_{pbt}$ or

$HC_t < HC_{pt}$ and $CO_{bt} < CO_{pbt}$ and $NOx_{bt} < NOx_{pbt}$ or

$HC_t < HC_{pt}$ and $CO_t < CO_{pt}$ and $NOx_{bt} < NOx_{pbt}$ or

$HC_{bt} < HC_{pbt}$ and $CO_t < CO_{pt}$ and $NOx_{bt} < NOx_{pbt}$ or

$HC_{bt} < HC_{pbt}$ and $CO_t < CO_{pt}$ and $NOx_t < NOx_{pt}$ or

$HC_{bt} < HC_{pbt}$ and $CO_{bt} < CO_{pbt}$ and $NOx_t < NOx_{pt}$

IM240 FAST-PASS EMISSION STANDARDS
(grams)

Sec	Hydrocarbons						Carbon Monoxide						Oxides of Nitrogen		
	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2			
	0.80	0.50	1.25	0.75	2.00	1.25	15.0	12.0	20.0	16.0	30.0	24.0	2.0	2.5	3.0
30	0.124	n/a	0.247	n/a	0.407	n/a	0.693	n/a	1.502	n/a	3.804	n/a	0.167	0.262	0.419
31	0.126	n/a	0.253	n/a	0.415	n/a	0.773	n/a	1.546	n/a	3.985	n/a	0.177	0.275	0.425
32	0.129	n/a	0.258	n/a	0.423	n/a	0.837	n/a	1.568	n/a	4.215	n/a	0.188	0.301	0.431
33	0.135	n/a	0.263	n/a	0.436	n/a	0.851	n/a	1.582	n/a	4.440	n/a	0.214	0.317	0.449
34	0.140	n/a	0.268	n/a	0.451	n/a	0.853	n/a	1.593	n/a	4.579	n/a	0.232	0.327	0.476
35	0.146	n/a	0.277	n/a	0.464	n/a	0.857	n/a	1.602	n/a	4.688	n/a	0.240	0.330	0.497
36	0.150	n/a	0.283	n/a	0.468	n/a	0.900	n/a	1.621	n/a	4.749	n/a	0.243	0.332	0.515
37	0.153	n/a	0.293	n/a	0.475	n/a	0.960	n/a	1.631	n/a	4.783	n/a	0.245	0.334	0.516
38	0.156	n/a	0.297	n/a	0.487	n/a	1.034	n/a	1.702	n/a	4.813	n/a	0.246	0.336	0.519
39	0.160	n/a	0.298	n/a	0.506	n/a	1.070	n/a	1.784	n/a	4.876	n/a	0.246	0.337	0.527
40	0.165	n/a	0.313	n/a	0.530	n/a	1.076	n/a	1.879	n/a	5.104	n/a	0.250	0.354	0.542
41	0.169	n/a	0.320	n/a	0.549	n/a	1.083	n/a	2.162	n/a	5.217	n/a	0.260	0.366	0.560
42	0.172	n/a	0.327	n/a	0.569	n/a	1.102	n/a	2.307	n/a	5.383	n/a	0.277	0.410	0.598
43	0.173	n/a	0.342	n/a	0.588	n/a	1.111	n/a	2.343	n/a	5.571	n/a	0.311	0.414	0.616
44	0.177	n/a	0.360	n/a	0.609	n/a	1.114	n/a	2.376	n/a	5.888	n/a	0.328	0.438	0.645
45	0.197	n/a	0.376	n/a	0.621	n/a	1.157	n/a	2.406	n/a	6.199	n/a	0.343	0.477	0.670
46	0.200	n/a	0.389	n/a	0.636	n/a	1.344	n/a	2.433	n/a	6.245	n/a	0.359	0.506	0.691
47	0.208	n/a	0.408	n/a	0.649	n/a	1.482	n/a	2.458	n/a	6.318	n/a	0.373	0.518	0.716
48	0.221	n/a	0.423	n/a	0.666	n/a	1.530	n/a	2.483	n/a	6.418	n/a	0.383	0.522	0.735
49	0.232	n/a	0.434	n/a	0.679	n/a	1.542	n/a	2.774	n/a	6.540	n/a	0.385	0.526	0.765
50	0.235	n/a	0.444	n/a	0.696	n/a	1.553	n/a	2.844	n/a	6.690	n/a	0.400	0.554	0.802
51	0.238	n/a	0.454	n/a	0.712	n/a	1.571	n/a	2.900	n/a	6.875	n/a	0.410	0.574	0.836
52	0.240	n/a	0.465	n/a	0.727	n/a	1.595	n/a	2.936	n/a	7.029	n/a	0.434	0.587	0.868
53	0.242	n/a	0.472	n/a	0.745	n/a	1.633	n/a	3.133	n/a	7.129	n/a	0.464	0.601	0.890
54	0.246	n/a	0.478	n/a	0.760	n/a	1.685	n/a	3.304	n/a	7.359	n/a	0.472	0.615	0.918
55	0.249	n/a	0.485	n/a	0.776	n/a	1.689	n/a	3.407	n/a	7.722	n/a	0.480	0.629	0.936
56	0.252	n/a	0.493	n/a	0.797	n/a	1.693	n/a	3.456	n/a	8.017	n/a	0.491	0.643	0.947
57	0.261	n/a	0.500	n/a	0.814	n/a	1.700	n/a	3.480	n/a	8.249	n/a	0.500	0.667	0.958
58	0.271	n/a	0.505	n/a	0.826	n/a	1.723	n/a	3.518	n/a	8.425	n/a	0.506	0.678	0.970
59	0.276	n/a	0.514	n/a	0.837	n/a	1.852	n/a	3.560	n/a	8.563	n/a	0.509	0.683	0.982
60	0.278	n/a	0.537	n/a	0.849	n/a	1.872	n/a	3.593	n/a	8.686	n/a	0.512	0.686	0.994
61	0.280	n/a	0.540	n/a	0.862	n/a	1.872	n/a	3.628	n/a	8.804	n/a	0.516	0.693	1.019
62	0.282	n/a	0.543	n/a	0.872	n/a	1.872	n/a	3.641	n/a	8.916	n/a	0.519	0.699	1.042
63	0.283	n/a	0.546	n/a	0.887	n/a	1.900	n/a	3.655	n/a	9.025	n/a	0.523	0.703	1.049
64	0.284	n/a	0.551	n/a	0.895	n/a	1.917	n/a	3.680	n/a	9.138	n/a	0.529	0.707	1.058
65	0.285	n/a	0.559	n/a	0.903	n/a	1.944	n/a	3.700	n/a	9.250	n/a	0.533	0.711	1.062
66	0.286	n/a	0.567	n/a	0.925	n/a	2.000	n/a	3.728	n/a	9.354	n/a	0.535	0.716	1.064
67	0.288	n/a	0.575	n/a	0.933	n/a	2.060	n/a	3.857	n/a	9.457	n/a	0.540	0.721	1.070
68	0.291	n/a	0.588	n/a	0.945	n/a	2.064	n/a	3.894	n/a	9.575	n/a	0.551	0.726	1.077
69	0.294	n/a	0.595	n/a	0.959	n/a	2.076	n/a	3.943	n/a	9.728	n/a	0.563	0.742	1.085
70	0.296	n/a	0.601	n/a	0.970	n/a	2.104	n/a	3.983	n/a	9.938	n/a	0.575	0.759	1.092
71	0.298	n/a	0.606	n/a	0.980	n/a	2.117	n/a	4.009	n/a	10.140	n/a	0.588	0.773	1.101
72	0.300	n/a	0.610	n/a	0.988	n/a	2.125	n/a	4.023	n/a	10.222	n/a	0.600	0.784	1.111
73	0.302	n/a	0.617	n/a	0.997	n/a	2.130	n/a	4.023	n/a	10.261	n/a	0.603	0.790	1.121
74	0.304	n/a	0.631	n/a	1.022	n/a	2.138	n/a	4.053	n/a	10.278	n/a	0.604	0.794	1.131

75	0.307	n/a	0.643	n/a	1.037	n/a	2.152	n/a	4.063	n/a	10.290	n/a	0.613	0.799	1.141
76	0.308	n/a	0.651	n/a	1.051	n/a	2.170	n/a	4.077	n/a	10.715	n/a	0.624	0.809	1.159
77	0.308	n/a	0.659	n/a	1.064	n/a	2.188	n/a	4.225	n/a	10.790	n/a	0.646	0.821	1.164
78	0.308	n/a	0.667	n/a	1.075	n/a	2.200	n/a	4.243	n/a	10.844	n/a	0.651	0.833	1.186
79	0.314	n/a	0.676	n/a	1.087	n/a	2.212	n/a	4.260	n/a	10.921	n/a	0.659	0.839	1.221
80	0.320	n/a	0.681	n/a	1.097	n/a	2.212	n/a	4.282	n/a	11.010	n/a	0.673	0.844	1.260
81	0.324	n/a	0.685	n/a	1.105	n/a	2.221	n/a	4.322	n/a	11.090	n/a	0.696	0.857	1.268
82	0.327	n/a	0.689	n/a	1.114	n/a	2.222	n/a	4.398	n/a	11.136	n/a	0.706	0.870	1.272
83	0.329	n/a	0.694	n/a	1.136	n/a	2.227	n/a	4.482	n/a	11.136	n/a	0.715	0.883	1.277
84	0.333	n/a	0.700	n/a	1.160	n/a	2.236	n/a	4.515	n/a	11.165	n/a	0.724	0.894	1.288
85	0.336	n/a	0.705	n/a	1.182	n/a	2.243	n/a	4.518	n/a	11.191	n/a	0.737	0.902	1.310
86	0.339	n/a	0.709	n/a	1.201	n/a	2.262	n/a	4.520	n/a	11.205	n/a	0.747	0.907	1.319
87	0.343	n/a	0.713	n/a	1.217	n/a	2.271	n/a	4.522	n/a	11.211	n/a	0.748	0.910	1.320
88	0.347	n/a	0.717	n/a	1.233	n/a	2.284	n/a	4.522	n/a	11.211	n/a	0.748	0.912	1.337
89	0.350	n/a	0.721	n/a	1.248	n/a	2.299	n/a	4.523	n/a	11.211	n/a	0.748	0.913	1.348
90	0.356	n/a	0.724	n/a	1.262	n/a	2.308	n/a	4.526	n/a	11.211	n/a	0.748	0.914	1.361
91	0.358	n/a	0.727	n/a	1.271	n/a	2.326	n/a	4.527	n/a	11.220	n/a	0.748	0.915	1.366
92	0.360	n/a	0.729	n/a	1.279	n/a	2.330	n/a	4.527	n/a	11.294	n/a	0.748	0.916	1.369
93	0.363	n/a	0.731	n/a	1.287	n/a	2.331	n/a	4.528	n/a	11.332	n/a	0.748	0.917	1.373
94	0.367	n/a	0.734	n/a	1.295	n/a	2.344	n/a	4.528	n/a	11.355	n/a	0.748	0.918	1.375
95	0.370	n/a	0.740	n/a	1.302	n/a	2.347	n/a	4.528	n/a	11.383	n/a	0.748	0.919	1.377
96	0.372	n/a	0.748	n/a	1.309	n/a	2.355	n/a	4.529	n/a	11.410	n/a	0.748	0.920	1.379
97	0.376	n/a	0.759	n/a	1.316	n/a	2.395	n/a	4.575	n/a	11.433	n/a	0.748	0.921	1.381
98	0.388	n/a	0.771	n/a	1.325	n/a	2.451	n/a	4.703	n/a	11.516	n/a	0.748	0.922	1.383
99	0.396	n/a	0.783	n/a	1.339	n/a	2.508	n/a	4.805	n/a	11.820	n/a	0.751	0.924	1.385
100	0.405	n/a	0.793	n/a	1.356	n/a	2.590	n/a	4.886	n/a	12.104	n/a	0.764	0.929	1.399
101	0.410	n/a	0.810	n/a	1.365	n/a	2.660	n/a	4.957	n/a	12.344	n/a	0.789	0.941	1.405
102	0.411	n/a	0.823	n/a	1.378	n/a	2.749	n/a	5.104	n/a	12.781	n/a	0.822	0.970	1.466
103	0.412	n/a	0.836	n/a	1.397	n/a	2.913	n/a	5.340	n/a	13.472	n/a	0.867	1.027	1.485
104	0.413	n/a	0.853	n/a	1.420	n/a	3.162	n/a	5.496	n/a	14.405	n/a	0.905	1.093	1.546
105	0.421	n/a	0.871	n/a	1.445	n/a	3.170	n/a	5.625	n/a	14.808	n/a	0.925	1.155	1.623
106	0.428	n/a	0.887	n/a	1.470	n/a	3.197	n/a	5.815	n/a	14.965	n/a	0.955	1.234	1.699
107	0.430	n/a	0.899	n/a	1.491	n/a	3.288	n/a	6.473	n/a	15.121	n/a	0.985	1.275	1.760
108	0.455	n/a	0.931	n/a	1.506	n/a	3.419	n/a	7.037	n/a	15.372	n/a	0.993	1.305	1.788
109	0.459	0.015	0.947	0.040	1.517	0.151	3.587	0.168	7.419	0.246	15.530	1.113	0.995	1.320	1.798
110	0.462	0.017	0.957	0.047	1.528	0.159	3.595	0.173	7.643	0.257	15.687	1.213	0.996	1.332	1.842
111	0.464	0.021	0.965	0.052	1.542	0.172	3.640	0.237	7.759	0.286	16.018	1.344	1.010	1.346	1.864
112	0.466	0.024	0.971	0.056	1.559	0.186	3.740	0.266	7.824	0.379	16.527	1.399	1.028	1.358	1.888
113	0.468	0.024	0.977	0.061	1.578	0.199	3.868	0.280	7.889	0.425	16.810	1.520	1.034	1.378	1.905
114	0.471	0.025	0.983	0.064	1.594	0.207	3.877	0.291	7.960	0.457	16.961	1.640	1.044	1.406	1.920
115	0.488	0.026	1.003	0.072	1.605	0.216	3.934	0.314	8.024	0.477	17.120	1.684	1.059	1.426	1.926
116	0.513	0.029	1.030	0.081	1.615	0.229	4.015	0.331	8.076	0.494	17.135	1.693	1.075	1.438	1.939
117	0.538	0.032	1.041	0.082	1.625	0.235	4.061	0.345	8.111	0.504	17.249	1.786	1.080	1.448	1.958
118	0.561	0.035	1.050	0.083	1.642	0.240	4.063	0.350	8.130	0.512	17.451	2.007	1.080	1.460	1.972
119	0.577	0.035	1.052	0.092	1.670	0.245	4.079	0.356	8.148	0.519	17.509	2.084	1.081	1.462	1.981
120	0.580	0.036	1.055	0.094	1.694	0.261	4.140	0.367	8.211	0.529	17.605	2.179	1.091	1.467	1.987
121	0.586	0.038	1.061	0.097	1.705	0.267	4.185	0.388	8.478	0.529	17.734	2.264	1.096	1.476	1.991
122	0.594	0.040	1.071	0.100	1.717	0.277	4.199	0.407	8.548	0.530	18.049	2.328	1.111	1.494	1.996
123	0.603	0.041	1.081	0.103	1.732	0.287	4.205	0.463	8.561	0.531	18.447	2.375	1.122	1.505	2.012
124	0.610	0.042	1.091	0.106	1.747	0.298	4.212	0.480	8.568	0.532	18.592	2.437	1.135	1.517	2.040
125	0.615	0.042	1.102	0.108	1.763	0.308	4.232	0.506	8.572	0.533	18.657	2.543	1.138	1.546	2.060
126	0.624	0.042	1.110	0.110	1.779	0.316	4.298	0.518	8.584	0.548	18.796	2.593	1.139	1.569	2.069
127	0.628	0.045	1.116	0.112	1.795	0.322	4.344	0.522	8.592	0.610	18.952	2.641	1.139	1.586	2.092

128	0.632	0.046	1.121	0.114	1.810	0.329	4.361	0.525	8.596	0.614	19.137	2.663	1.139	1.596	2.114
129	0.637	0.046	1.125	0.116	1.823	0.338	4.366	0.528	8.597	0.622	19.329	2.672	1.139	1.603	2.132
130	0.641	0.049	1.128	0.118	1.835	0.346	4.369	0.530	8.601	0.631	19.519	2.676	1.139	1.605	2.144
131	0.643	0.050	1.130	0.120	1.845	0.354	4.372	0.530	8.605	0.640	19.707	2.683	1.139	1.606	2.152
132	0.644	0.052	1.132	0.122	1.854	0.356	4.435	0.534	8.608	0.646	19.882	2.817	1.139	1.607	2.157
133	0.645	0.054	1.134	0.123	1.862	0.357	4.523	0.550	8.626	0.650	19.905	2.992	1.139	1.607	2.160
134	0.647	0.054	1.135	0.124	1.870	0.359	4.524	0.554	8.650	0.652	20.049	3.111	1.139	1.608	2.163
135	0.651	0.054	1.143	0.127	1.883	0.362	4.525	0.590	8.660	0.738	20.460	3.234	1.139	1.614	2.165
136	0.658	0.055	1.147	0.130	1.888	0.364	4.531	0.616	8.767	0.754	20.746	3.304	1.160	1.616	2.168
137	0.663	0.055	1.156	0.134	1.896	0.368	4.534	0.639	9.029	0.780	21.068	3.310	1.174	1.631	2.171
138	0.666	0.056	1.163	0.139	1.911	0.378	4.542	0.653	9.238	0.795	21.380	3.320	1.183	1.643	2.186
139	0.668	0.059	1.186	0.146	1.928	0.391	4.553	0.662	9.389	0.804	21.748	3.354	1.197	1.656	2.235
140	0.670	0.061	1.253	0.149	1.949	0.402	4.554	0.683	9.493	0.810	22.046	3.436	1.223	1.673	2.298
141	0.672	0.061	1.262	0.151	1.969	0.408	4.554	0.696	9.583	0.815	22.348	3.443	1.255	1.703	2.333
142	0.675	0.061	1.271	0.153	1.982	0.422	4.554	0.708	9.626	0.818	22.397	3.452	1.272	1.739	2.373
143	0.678	0.063	1.277	0.155	1.999	0.428	4.554	0.721	9.669	0.821	22.407	3.490	1.286	1.767	2.406
144	0.681	0.064	1.283	0.157	2.011	0.432	4.554	0.739	9.716	0.825	22.417	3.552	1.304	1.774	2.416
145	0.684	0.065	1.291	0.162	2.022	0.434	4.554	0.742	9.763	0.840	22.922	3.588	1.307	1.785	2.420
146	0.686	0.066	1.294	0.164	2.035	0.439	4.554	0.743	9.809	0.847	22.951	3.600	1.312	1.806	2.424
147	0.688	0.067	1.296	0.166	2.043	0.450	4.554	0.745	9.852	0.855	22.976	3.616	1.317	1.830	2.435
148	0.690	0.068	1.298	0.168	2.049	0.460	4.554	0.748	9.885	0.865	23.017	3.627	1.321	1.844	2.455
149	0.692	0.069	1.303	0.169	2.063	0.467	4.554	0.751	9.932	0.874	23.073	3.636	1.325	1.845	2.471
150	0.694	0.070	1.316	0.170	2.085	0.472	4.554	0.762	9.986	0.891	23.161	3.676	1.328	1.846	2.484
151	0.696	0.071	1.330	0.171	2.104	0.480	4.556	0.789	10.039	0.914	23.218	3.882	1.332	1.852	2.495
152	0.698	0.072	1.342	0.172	2.117	0.491	4.556	0.790	10.072	0.929	23.253	4.011	1.338	1.868	2.509
153	0.700	0.073	1.348	0.173	2.127	0.503	4.565	0.794	10.090	0.937	23.337	4.047	1.344	1.877	2.522
154	0.702	0.073	1.353	0.175	2.138	0.505	4.612	0.799	10.105	0.942	23.425	4.067	1.350	1.879	2.533
155	0.704	0.074	1.362	0.178	2.152	0.515	4.834	0.805	10.146	0.949	23.534	4.081	1.357	1.886	2.541
156	0.706	0.077	1.365	0.180	2.168	0.522	5.702	0.842	10.245	1.375	23.652	4.116	1.365	1.900	2.552
157	0.708	0.079	1.366	0.189	2.186	0.527	5.841	0.990	10.397	1.576	23.739	4.251	1.379	1.910	2.589
158	0.710	0.082	1.373	0.198	2.205	0.537	6.170	1.038	10.923	1.943	24.606	5.099	1.414	1.936	2.631
159	0.712	0.082	1.397	0.203	2.224	0.549	6.670	1.357	11.970	2.820	25.615	5.383	1.466	1.954	2.704
160	0.716	0.086	1.423	0.207	2.242	0.568	7.425	1.455	13.421	3.281	26.073	6.362	1.514	1.986	2.758
161	0.750	0.095	1.440	0.214	2.268	0.586	8.379	1.546	15.289	3.483	28.496	7.926	1.559	2.050	2.802
162	0.784	0.107	1.452	0.221	2.308	0.610	9.648	1.824	15.912	3.620	29.772	8.429	1.591	2.131	2.904
163	0.805	0.115	1.465	0.229	2.352	0.648	10.918	2.746	16.530	4.168	31.056	9.201	1.641	2.235	2.960
164	0.840	0.122	1.509	0.247	2.406	0.677	12.157	3.073	17.622	4.338	33.351	10.825	1.719	2.320	3.027
165	0.853	0.127	1.533	0.274	2.421	0.699	12.731	3.633	18.366	4.682	34.890	12.291	1.777	2.395	3.127
166	0.874	0.159	1.555	0.309	2.435	0.720	12.831	4.505	19.869	5.633	35.937	13.366	1.832	2.488	3.187
167	0.903	0.186	1.576	0.318	2.470	0.738	12.892	4.952	20.711	6.137	37.012	14.428	1.919	2.563	3.306
168	0.910	0.189	1.598	0.322	2.501	0.767	12.932	5.254	22.319	6.853	37.892	15.318	1.972	2.645	3.384
169	0.914	0.200	1.618	0.333	2.537	0.828	13.702	5.730	23.751	7.136	39.028	15.699	2.013	2.746	3.467
170	0.916	0.220	1.636	0.343	2.571	0.855	14.139	6.051	24.842	7.320	40.406	16.073	2.100	2.778	3.565
171	0.919	0.236	1.666	0.356	2.625	0.869	14.964	6.333	25.410	7.685	41.379	16.475	2.200	2.792	3.640
172	0.931	0.247	1.685	0.385	2.657	0.885	15.704	6.490	25.798	8.052	42.033	17.158	2.251	2.810	3.718
173	0.948	0.257	1.726	0.409	2.683	0.900	16.253	6.796	26.122	8.344	42.432	17.532	2.270	2.847	3.781
174	0.983	0.267	1.742	0.433	2.701	0.941	16.907	7.205	26.353	8.602	42.742	17.965	2.301	2.874	3.827
175	1.018	0.283	1.756	0.453	2.717	0.979	17.655	8.151	26.638	8.898	43.399	18.242	2.318	2.905	3.852
176	1.027	0.295	1.769	0.463	2.732	1.002	18.020	8.230	27.219	9.251	43.895	18.283	2.335	2.950	3.903
177	1.035	0.312	1.784	0.507	2.756	1.025	18.349	8.584	27.279	10.253	44.227	18.480	2.349	3.001	3.930
178	1.051	0.318	1.802	0.523	2.781	1.047	18.671	8.800	27.320	10.828	44.926	19.576	2.387	3.047	3.970
179	1.074	0.323	1.822	0.528	2.811	1.065	18.972	8.847	27.352	10.933	45.256	20.015	2.423	3.104	4.015
180	1.084	0.337	1.843	0.541	2.853	1.089	19.228	8.913	27.822	11.060	45.553	20.203	2.462	3.173	4.074

181	1.099	0.345	1.864	0.549	2.898	1.109	20.123	9.122	28.763	11.188	45.753	20.433	2.503	3.238	4.159
182	1.121	0.350	1.884	0.559	2.946	1.133	20.405	9.532	29.402	11.345	46.210	21.025	2.545	3.302	4.230
183	1.132	0.359	1.896	0.571	2.988	1.158	20.754	10.256	29.971	11.733	47.017	21.882	2.586	3.372	4.286
184	1.152	0.387	1.915	0.584	3.023	1.184	21.684	10.862	30.276	12.598	48.185	22.204	2.627	3.452	4.334
185	1.161	0.398	1.940	0.598	3.057	1.209	21.955	10.996	30.988	12.953	48.741	22.859	2.673	3.545	4.388
186	1.168	0.400	1.958	0.613	3.076	1.222	22.650	11.206	31.095	13.213	49.462	23.533	2.749	3.648	4.447
187	1.175	0.402	1.972	0.624	3.101	1.231	22.989	11.514	31.314	14.131	50.313	24.281	2.804	3.701	4.505
188	1.181	0.405	1.985	0.629	3.120	1.239	23.535	11.894	31.833	14.839	51.285	25.078	2.851	3.759	4.561
189	1.188	0.418	1.991	0.629	3.136	1.254	23.876	12.019	32.239	15.137	52.076	25.276	2.894	3.821	4.625
190	1.203	0.429	1.993	0.638	3.151	1.278	24.018	12.170	32.547	15.138	52.857	25.578	2.931	3.870	4.696
191	1.219	0.442	1.995	0.648	3.163	1.300	24.464	12.517	32.855	15.141	52.876	25.859	2.971	3.892	4.731
192	1.233	0.457	2.001	0.659	3.209	1.313	24.685	12.598	33.153	15.595	53.067	25.985	3.020	3.914	4.780
193	1.251	0.473	2.015	0.663	3.223	1.324	24.931	12.625	33.444	15.658	53.777	26.153	3.077	3.955	4.837
194	1.255	0.487	2.031	0.671	3.237	1.340	25.188	12.653	33.482	15.704	54.242	26.582	3.132	3.997	4.876
195	1.258	0.501	2.047	0.681	3.263	1.367	25.468	12.777	33.516	15.729	54.489	27.067	3.185	4.035	4.928
196	1.265	0.510	2.063	0.693	3.302	1.387	25.627	12.906	33.549	16.058	54.601	27.456	3.219	4.089	4.972
197	1.280	0.512	2.079	0.709	3.338	1.402	25.746	12.989	33.653	16.987	54.912	27.805	3.268	4.146	5.025
198	1.293	0.514	2.094	0.725	3.372	1.417	25.850	13.060	33.973	17.064	55.588	28.070	3.299	4.206	5.104
199	1.301	0.516	2.109	0.740	3.390	1.432	25.974	13.165	34.159	17.073	56.266	28.590	3.350	4.243	5.189
200	1.313	0.518	2.122	0.754	3.428	1.446	26.141	13.242	34.191	17.153	56.617	28.914	3.406	4.295	5.275
201	1.324	0.527	2.130	0.767	3.470	1.460	26.225	13.412	34.250	17.332	56.863	29.063	3.466	4.351	5.336
202	1.332	0.540	2.137	0.775	3.493	1.477	26.338	13.662	34.469	17.406	57.204	29.502	3.497	4.398	5.366
203	1.341	0.547	2.157	0.787	3.509	1.492	26.547	13.773	34.716	17.641	57.371	29.697	3.514	4.410	5.387
204	1.357	0.553	2.172	0.795	3.522	1.501	26.818	13.942	34.969	17.922	57.487	29.713	3.517	4.419	5.427
205	1.375	0.559	2.194	0.803	3.533	1.510	27.052	14.090	35.144	18.484	57.728	29.783	3.519	4.426	5.444
206	1.392	0.563	2.222	0.854	3.550	1.522	27.393	14.224	35.418	18.553	58.097	29.942	3.523	4.429	5.447
207	1.408	0.567	2.245	0.859	3.578	1.561	27.501	14.426	35.766	18.658	58.572	30.284	3.545	4.453	5.477
208	1.422	0.571	2.268	0.872	3.607	1.585	27.632	14.498	35.949	18.953	59.024	30.755	3.570	4.486	5.520
209	1.433	0.575	2.279	0.892	3.630	1.597	27.803	14.776	36.010	19.266	59.321	31.287	3.600	4.542	5.560
210	1.443	0.579	2.288	0.896	3.658	1.607	27.953	14.907	36.548	19.309	59.715	31.549	3.619	4.598	5.603
211	1.453	0.595	2.301	0.903	3.701	1.627	28.205	14.916	37.179	19.731	60.045	31.820	3.639	4.638	5.657
212	1.463	0.605	2.316	0.924	3.745	1.645	28.543	15.014	37.651	19.902	60.453	32.250	3.686	4.715	5.698
213	1.468	0.614	2.332	0.938	3.778	1.656	28.997	15.221	38.041	20.012	60.935	32.546	3.732	4.774	5.762
214	1.470	0.622	2.345	0.941	3.814	1.663	29.000	15.472	38.591	20.260	61.307	32.808	3.791	4.829	5.827
215	1.474	0.627	2.354	0.951	3.825	1.669	29.005	15.555	38.852	20.739	61.666	33.060	3.833	4.872	5.849
216	1.478	0.638	2.362	0.966	3.835	1.674	29.081	15.652	38.861	21.346	62.148	33.204	3.890	4.931	5.884
217	1.481	0.643	2.368	0.979	3.844	1.685	29.281	15.969	38.926	21.810	62.532	33.341	3.932	4.960	5.908
218	1.484	0.643	2.376	0.980	3.853	1.700	29.483	16.028	39.194	22.001	62.546	33.414	3.960	4.963	5.921
219	1.487	0.645	2.384	0.981	3.864	1.704	29.734	16.375	39.474	22.290	62.559	33.514	3.997	4.965	5.931
220	1.490	0.651	2.391	1.005	3.874	1.706	29.803	16.487	39.668	22.324	62.570	33.640	4.013	4.968	5.939
221	1.493	0.655	2.395	1.016	3.891	1.709	29.821	16.524	39.781	22.343	62.846	33.692	4.035	4.971	5.947
222	1.504	0.663	2.400	1.022	3.928	1.711	29.847	16.578	39.890	22.522	63.097	33.711	4.038	4.974	5.952
223	1.522	0.671	2.405	1.028	3.966	1.714	29.862	16.684	39.954	22.661	63.150	33.733	4.050	4.977	5.955
224	1.547	0.675	2.409	1.035	4.008	1.718	29.873	16.755	39.984	22.666	63.150	33.770	4.066	4.979	5.957
225	1.549	0.684	2.413	1.041	4.010	1.721	30.008	16.770	39.989	22.667	63.150	33.796	4.070	4.980	5.959
226	1.562	0.694	2.415	1.045	4.012	1.723	30.126	16.805	39.990	22.668	63.150	33.810	4.072	4.981	5.961
227	1.574	0.701	2.417	1.051	4.016	1.726	30.127	16.865	39.990	22.669	63.150	33.821	4.072	4.982	5.963
228	1.579	0.702	2.419	1.055	4.019	1.729	30.127	16.960	39.990	22.670	63.150	33.839	4.073	4.983	5.966
229	1.584	0.708	2.420	1.059	4.057	1.731	30.208	16.960	39.991	22.671	63.150	33.865	4.073	4.984	5.971
230	1.589	0.708	2.421	1.062	4.065	1.733	30.314	16.962	40.012	22.671	63.150	33.894	4.073	4.985	5.977
231	1.590	0.709	2.423	1.063	4.071	1.735	30.323	16.988	40.061	22.672	63.150	33.918	4.073	4.986	5.984
232	1.596	0.710	2.425	1.063	4.073	1.743	30.325	17.072	40.116	22.673	63.150	33.944	4.074	4.987	5.990
233	1.598	0.710	2.427	1.063	4.075	1.749	30.368	17.094	40.249	22.673	63.150	33.985	4.074	4.988	5.997

234	1.604	0.711	2.429	1.064	4.077	1.753	30.411	17.184	40.253	22.673	63.153	34.014	4.075	4.989	6.004
235	1.610	0.712	2.430	1.064	4.079	1.757	30.416	17.187	40.290	22.674	63.159	34.032	4.075	4.990	6.012
236	1.612	0.712	2.431	1.066	4.081	1.762	30.428	17.188	40.385	22.675	63.173	34.051	4.076	4.991	6.024
237	1.613	0.712	2.432	1.069	4.083	1.767	30.430	17.189	40.488	22.675	63.193	34.067	4.076	4.992	6.037
238	1.614	0.713	2.433	1.072	4.084	1.772	30.452	17.241	40.720	22.675	63.214	34.079	4.076	4.993	6.049
239	1.615	0.716	2.434	1.075	4.085	1.776	30.488	17.370	40.763	22.677	63.233	34.085	4.076	4.994	6.060

Appendix B
Alternative Fast-Pass IM240 Standards

Alternative Fast-Pass IM240 Standards
Corresponding to Composite Start-up Emission Standards
in §85.2205(a)(2)(i) and §85.2205(a)(2)(ii)
Light Duty Vehicles

Sec	Low Altitude 1981-1982			Low Altitude 1983-1990			Low Altitude 1991-1995			High Altitude 1982		
	HC	CO	NOx	HC	CO	NOx	HC	CO	NOx	HC	CO	NOx
30	0.330	4.189	0.250	0.330	1.941	0.251	0.174	1.307	0.222	0.330	7.391	0.250
31	0.342	4.278	0.267	0.342	1.983	0.268	0.179	1.329	0.246	0.342	7.667	0.267
32	0.353	4.366	0.283	0.353	2.025	0.285	0.184	1.350	0.270	0.353	7.944	0.283
33	0.364	4.455	0.300	0.365	2.067	0.302	0.189	1.372	0.294	0.364	8.220	0.300
34	0.375	4.544	0.316	0.376	2.108	0.320	0.194	1.394	0.318	0.375	8.497	0.316
35	0.386	4.633	0.333	0.388	2.150	0.337	0.199	1.416	0.342	0.386	8.773	0.333
36	0.398	4.728	0.336	0.399	2.230	0.339	0.201	1.453	0.345	0.398	9.011	0.336
37	0.409	4.823	0.339	0.410	2.310	0.342	0.203	1.490	0.348	0.409	9.249	0.339
38	0.420	4.917	0.342	0.420	2.390	0.344	0.205	1.527	0.350	0.420	9.488	0.342
39	0.431	5.012	0.345	0.431	2.471	0.347	0.207	1.565	0.353	0.431	9.726	0.345
40	0.443	5.107	0.348	0.442	2.551	0.349	0.209	1.602	0.356	0.443	9.964	0.348
41	0.458	5.429	0.371	0.458	2.738	0.373	0.214	1.642	0.373	0.458	10.527	0.371
42	0.474	5.751	0.394	0.473	2.926	0.397	0.219	1.682	0.390	0.474	11.090	0.394
43	0.489	6.073	0.418	0.489	3.114	0.422	0.224	1.722	0.407	0.489	11.652	0.418
44	0.505	6.395	0.441	0.505	3.302	0.446	0.228	1.763	0.425	0.505	12.215	0.441
45	0.521	6.717	0.465	0.520	3.489	0.470	0.233	1.803	0.442	0.521	12.778	0.465
46	0.535	6.985	0.480	0.536	3.589	0.486	0.238	1.867	0.465	0.535	13.265	0.480
47	0.550	7.254	0.496	0.552	3.688	0.501	0.244	1.932	0.487	0.550	13.751	0.496
48	0.565	7.522	0.512	0.568	3.787	0.517	0.250	1.997	0.510	0.565	14.238	0.512
49	0.580	7.791	0.527	0.584	3.887	0.533	0.255	2.061	0.533	0.580	14.724	0.527
50	0.594	8.060	0.543	0.600	3.986	0.549	0.261	2.126	0.555	0.594	15.211	0.543
51	0.611	8.511	0.567	0.617	4.029	0.571	0.268	2.152	0.573	0.611	15.550	0.567
52	0.628	8.962	0.590	0.633	4.072	0.594	0.275	2.179	0.590	0.628	15.889	0.590
53	0.644	9.413	0.613	0.649	4.115	0.616	0.282	2.205	0.608	0.644	16.228	0.613
54	0.661	9.865	0.637	0.665	4.157	0.638	0.290	2.232	0.625	0.661	16.567	0.637
55	0.678	10.316	0.660	0.681	4.200	0.661	0.297	2.258	0.643	0.678	16.907	0.660
56	0.691	10.818	0.675	0.696	4.263	0.676	0.302	2.348	0.654	0.691	17.199	0.675
57	0.705	11.320	0.689	0.710	4.326	0.691	0.306	2.437	0.666	0.705	17.492	0.689
58	0.718	11.822	0.703	0.725	4.388	0.707	0.311	2.526	0.677	0.718	17.785	0.703
59	0.731	12.325	0.718	0.740	4.451	0.722	0.316	2.616	0.688	0.731	18.078	0.718
60	0.745	12.827	0.732	0.754	4.514	0.737	0.320	2.705	0.700	0.745	18.371	0.732
61	0.758	13.228	0.743	0.767	4.589	0.748	0.323	2.726	0.707	0.758	18.609	0.743
62	0.772	13.629	0.754	0.780	4.664	0.758	0.326	2.746	0.714	0.772	18.847	0.754
63	0.786	14.029	0.764	0.794	4.740	0.769	0.329	2.767	0.722	0.786	19.085	0.764
64	0.799	14.430	0.775	0.807	4.815	0.780	0.332	2.787	0.729	0.799	19.323	0.775
65	0.813	14.831	0.786	0.820	4.891	0.790	0.335	2.808	0.736	0.813	19.562	0.786
66	0.827	15.046	0.794	0.833	4.945	0.799	0.340	2.812	0.742	0.827	19.887	0.794
67	0.841	15.261	0.803	0.846	4.999	0.808	0.345	2.816	0.747	0.841	20.213	0.803

68	0.855	15.476	0.811	0.859	5.053	0.817	0.350	2.820	0.753	0.855	20.539	0.811
69	0.869	15.692	0.820	0.872	5.107	0.826	0.355	2.825	0.758	0.869	20.865	0.820
70	0.883	15.907	0.828	0.885	5.162	0.835	0.360	2.829	0.764	0.883	21.191	0.828
71	0.894	16.118	0.838	0.896	5.226	0.846	0.364	2.847	0.783	0.894	21.396	0.838
72	0.905	16.330	0.848	0.906	5.291	0.857	0.367	2.865	0.802	0.905	21.602	0.848
73	0.917	16.542	0.858	0.917	5.356	0.868	0.371	2.884	0.822	0.917	21.808	0.858
74	0.928	16.753	0.868	0.928	5.421	0.878	0.375	2.902	0.841	0.928	22.013	0.868
75	0.939	16.965	0.878	0.939	5.486	0.889	0.378	2.921	0.860	0.939	22.219	0.878
76	0.953	17.199	0.891	0.952	5.553	0.900	0.387	2.982	0.874	0.953	22.685	0.891
77	0.967	17.432	0.904	0.965	5.620	0.911	0.396	3.044	0.888	0.967	23.151	0.904
78	0.981	17.666	0.917	0.978	5.687	0.922	0.405	3.106	0.902	0.981	23.617	0.917
79	0.994	17.900	0.930	0.991	5.754	0.933	0.414	3.167	0.916	0.994	24.083	0.930
80	1.008	18.133	0.944	1.004	5.821	0.944	0.423	3.229	0.930	1.008	24.549	0.944
81	1.019	18.182	0.951	1.015	5.842	0.951	0.428	3.240	0.945	1.019	24.570	0.951
82	1.031	18.231	0.958	1.026	5.863	0.959	0.432	3.250	0.959	1.031	24.591	0.958
83	1.042	18.280	0.965	1.037	5.883	0.966	0.437	3.261	0.973	1.042	24.612	0.965
84	1.053	18.329	0.972	1.048	5.904	0.973	0.441	3.271	0.987	1.053	24.633	0.972
85	1.065	18.378	0.979	1.059	5.925	0.980	0.445	3.281	1.002	1.065	24.654	0.979
86	1.072	18.393	0.980	1.067	5.970	0.981	0.448	3.290	1.003	1.072	24.666	0.980
87	1.079	18.408	0.981	1.075	6.015	0.982	0.452	3.298	1.004	1.079	24.678	0.981
88	1.086	18.423	0.982	1.083	6.060	0.982	0.455	3.306	1.005	1.086	24.690	0.982
89	1.093	18.438	0.983	1.091	6.105	0.983	0.458	3.315	1.006	1.093	24.703	0.983
90	1.099	18.453	0.983	1.099	6.151	0.984	0.462	3.323	1.007	1.099	24.715	0.983
91	1.107	18.467	0.984	1.106	6.185	0.985	0.463	3.360	1.008	1.107	24.737	0.984
92	1.114	18.481	0.985	1.114	6.219	0.986	0.464	3.397	1.008	1.114	24.758	0.985
93	1.121	18.495	0.985	1.122	6.253	0.986	0.465	3.434	1.009	1.121	24.780	0.985
94	1.128	18.509	0.986	1.129	6.287	0.987	0.466	3.470	1.009	1.128	24.801	0.986
95	1.135	18.523	0.986	1.137	6.321	0.988	0.468	3.507	1.010	1.135	24.823	0.986
96	1.149	18.681	0.992	1.150	6.489	0.993	0.472	3.536	1.011	1.149	25.193	0.992
97	1.162	18.840	0.997	1.163	6.657	0.999	0.477	3.565	1.012	1.162	25.563	0.997
98	1.176	18.998	1.002	1.176	6.825	1.004	0.481	3.594	1.013	1.176	25.933	1.002
99	1.189	19.157	1.008	1.189	6.992	1.009	0.486	3.623	1.014	1.189	26.303	1.008
100	1.203	19.315	1.013	1.202	7.160	1.014	0.490	3.651	1.015	1.203	26.672	1.013
101	1.223	20.090	1.049	1.224	7.269	1.049	0.499	3.685	1.042	1.223	27.821	1.049
102	1.244	20.864	1.085	1.245	7.378	1.084	0.509	3.719	1.069	1.244	28.969	1.085
103	1.264	21.639	1.121	1.266	7.487	1.119	0.518	3.753	1.097	1.264	30.117	1.121
104	1.285	22.414	1.157	1.287	7.596	1.154	0.527	3.787	1.124	1.285	31.265	1.157
105	1.305	23.189	1.193	1.309	7.705	1.189	0.537	3.821	1.151	1.305	32.414	1.193
106	1.319	23.461	1.224	1.323	7.835	1.215	0.541	3.842	1.194	1.319	33.103	1.224
107	1.333	23.733	1.255	1.338	7.965	1.241	0.545	3.863	1.237	1.333	33.792	1.255
108	1.346	24.006	1.286	1.352	8.095	1.267	0.548	3.884	1.280	1.346	34.481	1.286
109	1.360	24.278	1.317	1.367	8.225	1.293	0.552	3.904	1.323	1.360	35.170	1.317
110	1.374	24.550	1.348	1.382	8.355	1.319	0.556	3.925	1.366	1.374	35.859	1.348
111	1.385	24.846	1.356	1.394	8.414	1.327	0.562	3.931	1.368	1.385	36.177	1.356
112	1.396	25.141	1.363	1.406	8.472	1.336	0.568	3.937	1.371	1.396	36.495	1.363

113	1.407	25.437	1.371	1.418	8.531	1.345	0.574	3.943	1.374	1.407	36.813	1.371
114	1.417	25.732	1.378	1.430	8.590	1.354	0.580	3.949	1.377	1.417	37.132	1.378
115	1.428	26.028	1.386	1.442	8.649	1.363	0.586	3.956	1.380	1.428	37.450	1.386
116	1.437	26.045	1.388	1.451	8.735	1.364	0.590	3.975	1.380	1.437	37.554	1.388
117	1.446	26.062	1.389	1.460	8.821	1.365	0.593	3.995	1.381	1.446	37.658	1.389
118	1.455	26.079	1.391	1.469	8.907	1.366	0.597	4.015	1.382	1.455	37.761	1.391
119	1.464	26.096	1.393	1.479	8.992	1.368	0.600	4.035	1.383	1.464	37.865	1.393
120	1.472	26.114	1.394	1.488	9.078	1.369	0.604	4.055	1.383	1.472	37.969	1.394
121	1.488	26.293	1.408	1.501	9.152	1.385	0.610	4.152	1.400	1.488	38.310	1.408
122	1.503	26.472	1.422	1.514	9.227	1.401	0.615	4.250	1.417	1.503	38.650	1.422
123	1.518	26.651	1.435	1.527	9.301	1.417	0.621	4.348	1.433	1.518	38.990	1.435
124	1.534	26.830	1.449	1.540	9.375	1.434	0.627	4.445	1.450	1.534	39.330	1.449
125	1.549	27.010	1.463	1.553	9.449	1.450	0.632	4.543	1.466	1.549	39.671	1.463
126	1.559	27.151	1.471	1.563	9.519	1.458	0.636	4.567	1.470	1.559	39.865	1.471
127	1.569	27.292	1.479	1.572	9.590	1.467	0.639	4.592	1.473	1.569	40.059	1.479
128	1.579	27.433	1.487	1.582	9.661	1.475	0.642	4.617	1.476	1.579	40.254	1.487
129	1.590	27.575	1.495	1.592	9.731	1.484	0.645	4.641	1.479	1.590	40.448	1.495
130	1.600	27.716	1.502	1.601	9.802	1.492	0.648	4.666	1.482	1.600	40.642	1.502
131	1.612	27.878	1.506	1.615	9.849	1.496	0.653	4.685	1.483	1.612	40.790	1.506
132	1.624	28.040	1.509	1.628	9.895	1.500	0.657	4.704	1.485	1.624	40.937	1.509
133	1.635	28.202	1.512	1.642	9.942	1.504	0.661	4.724	1.486	1.635	41.084	1.512
134	1.647	28.365	1.515	1.655	9.989	1.508	0.666	4.743	1.488	1.647	41.231	1.515
135	1.659	28.527	1.519	1.669	10.035	1.512	0.670	4.762	1.489	1.659	41.379	1.519
136	1.676	28.833	1.542	1.685	10.104	1.534	0.678	4.785	1.507	1.676	42.023	1.542
137	1.693	29.140	1.566	1.700	10.173	1.557	0.685	4.807	1.524	1.693	42.668	1.566
138	1.709	29.446	1.589	1.716	10.241	1.580	0.693	4.830	1.541	1.709	43.312	1.589
139	1.726	29.753	1.613	1.732	10.310	1.603	0.700	4.853	1.559	1.726	43.957	1.613
140	1.743	30.060	1.636	1.747	10.378	1.626	0.708	4.875	1.576	1.743	44.602	1.636
141	1.756	30.160	1.651	1.762	10.506	1.640	0.716	4.886	1.592	1.756	45.010	1.651
142	1.770	30.260	1.666	1.777	10.633	1.655	0.723	4.897	1.608	1.770	45.419	1.666
143	1.783	30.361	1.681	1.791	10.761	1.669	0.731	4.908	1.624	1.783	45.828	1.681
144	1.797	30.461	1.696	1.806	10.888	1.684	0.738	4.918	1.640	1.797	46.237	1.696
145	1.810	30.562	1.711	1.821	11.016	1.699	0.746	4.929	1.656	1.810	46.646	1.711
146	1.822	30.592	1.720	1.830	11.101	1.709	0.751	4.954	1.663	1.822	46.945	1.720
147	1.834	30.622	1.730	1.840	11.187	1.720	0.755	4.979	1.671	1.834	47.244	1.730
148	1.846	30.653	1.740	1.850	11.273	1.730	0.760	5.004	1.679	1.846	47.544	1.740
149	1.858	30.683	1.750	1.860	11.359	1.741	0.765	5.029	1.687	1.858	47.843	1.750
150	1.869	30.713	1.760	1.869	11.445	1.752	0.770	5.054	1.694	1.869	48.143	1.760
151	1.880	30.741	1.767	1.879	11.504	1.759	0.775	5.060	1.711	1.880	48.423	1.767
152	1.890	30.768	1.775	1.890	11.564	1.767	0.780	5.065	1.727	1.890	48.704	1.775
153	1.900	30.796	1.783	1.900	11.624	1.775	0.785	5.070	1.743	1.900	48.984	1.783
154	1.910	30.823	1.791	1.910	11.683	1.783	0.791	5.075	1.760	1.910	49.265	1.791
155	1.920	30.850	1.798	1.920	11.743	1.790	0.796	5.080	1.776	1.920	49.545	1.798
156	1.949	32.415	1.828	1.945	12.434	1.821	0.819	5.150	1.813	1.949	50.517	1.828
157	1.977	33.980	1.858	1.971	13.125	1.852	0.842	5.220	1.850	1.977	51.489	1.858

158	2.006	35.545	1.888	1.996	13.816	1.883	0.865	5.290	1.887	2.006	52.461	1.888
159	2.034	37.110	1.918	2.022	14.507	1.913	0.888	5.360	1.924	2.034	53.433	1.918
160	2.063	38.674	1.948	2.047	15.198	1.944	0.911	5.430	1.961	2.063	54.406	1.948
161	2.105	41.040	2.043	2.092	16.627	2.038	0.951	7.045	2.030	2.105	56.279	2.043
162	2.147	43.405	2.138	2.137	18.056	2.133	0.992	8.661	2.099	2.147	58.152	2.138
163	2.190	45.770	2.234	2.182	19.485	2.227	1.032	10.276	2.168	2.190	60.026	2.234
164	2.232	48.136	2.329	2.227	20.914	2.321	1.073	11.891	2.237	2.232	61.899	2.329
165	2.275	50.501	2.424	2.272	22.343	2.415	1.113	13.506	2.306	2.275	63.773	2.424
166	2.304	52.979	2.509	2.300	23.672	2.502	1.163	14.131	2.357	2.304	65.726	2.509
167	2.333	55.458	2.593	2.328	25.002	2.589	1.213	14.755	2.409	2.333	67.678	2.593
168	2.362	57.937	2.678	2.356	26.331	2.676	1.263	15.380	2.460	2.362	69.631	2.678
169	2.391	60.415	2.762	2.385	27.660	2.763	1.313	16.004	2.512	2.391	71.584	2.762
170	2.420	62.894	2.847	2.413	28.989	2.849	1.363	16.628	2.564	2.420	73.536	2.847
171	2.451	63.874	2.890	2.442	29.484	2.892	1.386	16.692	2.603	2.451	75.553	2.890
172	2.481	64.855	2.933	2.472	29.978	2.934	1.410	16.756	2.643	2.481	77.570	2.933
173	2.512	65.835	2.976	2.502	30.473	2.976	1.433	16.820	2.683	2.512	79.587	2.976
174	2.542	66.815	3.019	2.532	30.967	3.019	1.457	16.883	2.723	2.542	81.604	3.019
175	2.573	67.796	3.062	2.562	31.462	3.061	1.480	16.947	2.762	2.573	83.621	3.062
176	2.598	68.919	3.122	2.588	32.216	3.119	1.494	17.044	2.809	2.598	85.074	3.122
177	2.623	70.042	3.181	2.615	32.970	3.178	1.508	17.141	2.856	2.623	86.528	3.181
178	2.648	71.165	3.240	2.641	33.725	3.236	1.522	17.238	2.903	2.648	87.981	3.240
179	2.674	72.287	3.300	2.668	34.479	3.295	1.536	17.335	2.949	2.674	89.434	3.300
180	2.699	73.410	3.359	2.694	35.233	3.353	1.550	17.431	2.996	2.699	90.888	3.359
181	2.726	74.714	3.432	2.718	35.950	3.424	1.565	17.453	3.040	2.726	92.421	3.432
182	2.753	76.017	3.504	2.743	36.666	3.495	1.580	17.475	3.084	2.753	93.953	3.504
183	2.780	77.320	3.576	2.767	37.382	3.567	1.595	17.497	3.129	2.780	95.486	3.576
184	2.807	78.623	3.648	2.791	38.099	3.638	1.610	17.519	3.173	2.807	97.019	3.648
185	2.834	79.927	3.720	2.816	38.815	3.709	1.624	17.540	3.217	2.834	98.552	3.720
186	2.861	81.488	3.804	2.843	39.562	3.795	1.639	17.816	3.277	2.861	100.583	3.804
187	2.888	83.049	3.889	2.869	40.309	3.880	1.654	18.091	3.337	2.888	102.615	3.889
188	2.915	84.611	3.973	2.896	41.056	3.965	1.668	18.366	3.397	2.915	104.646	3.973
189	2.942	86.172	4.057	2.923	41.803	4.051	1.683	18.641	3.457	2.942	106.677	4.057
190	2.969	87.733	4.141	2.950	42.550	4.136	1.697	18.916	3.518	2.969	108.709	4.141
191	2.994	88.668	4.196	2.975	43.279	4.190	1.711	19.891	3.565	2.994	110.057	4.196
192	3.019	89.603	4.250	3.001	44.008	4.243	1.724	20.866	3.612	3.019	111.405	4.250
193	3.044	90.538	4.304	3.027	44.737	4.297	1.737	21.840	3.658	3.044	112.753	4.304
194	3.070	91.473	4.358	3.052	45.466	4.351	1.750	22.815	3.705	3.070	114.101	4.358
195	3.095	92.407	4.412	3.078	46.195	4.404	1.763	23.790	3.752	3.095	115.449	4.412
196	3.120	93.768	4.485	3.105	46.747	4.477	1.778	24.992	3.794	3.120	116.561	4.485
197	3.145	95.129	4.558	3.132	47.299	4.549	1.793	26.194	3.836	3.145	117.674	4.558
198	3.169	96.490	4.630	3.159	47.852	4.622	1.808	27.396	3.877	3.169	118.786	4.630
199	3.194	97.851	4.703	3.186	48.404	4.694	1.823	28.597	3.919	3.194	119.899	4.703
200	3.219	99.212	4.775	3.213	48.957	4.767	1.838	29.799	3.960	3.219	121.011	4.775
201	3.242	99.878	4.821	3.234	49.204	4.812	1.858	29.975	4.004	3.242	121.695	4.821
202	3.266	100.544	4.867	3.255	49.451	4.858	1.877	30.152	4.047	3.266	122.378	4.867

203	**3.289**	**101.210**	**4.914**	**3.277**	**49.698**	**4.904**	**1.897**	**30.328**	**4.090**	**3.289**	**123.062**	**4.914**
204	**3.312**	**101.876**	**4.960**	**3.298**	**49.945**	**4.950**	**1.916**	**30.504**	**4.133**	**3.312**	**123.745**	**4.960**
205	**3.335**	**102.542**	**5.006**	**3.320**	**50.192**	**4.996**	**1.936**	**30.680**	**4.176**	**3.335**	**124.429**	**5.006**
206	**3.362**	**103.507**	**5.037**	**3.346**	**50.698**	**5.029**	**1.948**	**30.747**	**4.193**	**3.362**	**125.599**	**5.037**
207	**3.388**	**104.472**	**5.069**	**3.373**	**51.205**	**5.063**	**1.961**	**30.813**	**4.209**	**3.388**	**126.769**	**5.069**
208	**3.415**	**105.437**	**5.101**	**3.399**	**51.711**	**5.097**	**1.973**	**30.879**	**4.225**	**3.415**	**127.939**	**5.101**
209	**3.441**	**106.402**	**5.132**	**3.426**	**52.218**	**5.130**	**1.986**	**30.946**	**4.241**	**3.441**	**129.109**	**5.132**
210	**3.468**	**107.366**	**5.164**	**3.452**	**52.724**	**5.164**	**1.998**	**31.012**	**4.257**	**3.468**	**130.279**	**5.164**
211	**3.488**	**108.519**	**5.234**	**3.472**	**53.327**	**5.233**	**2.006**	**32.744**	**4.311**	**3.488**	**132.009**	**5.234**
212	**3.509**	**109.671**	**5.304**	**3.492**	**53.931**	**5.303**	**2.015**	**34.476**	**4.365**	**3.509**	**133.740**	**5.304**
213	**3.530**	**110.823**	**5.374**	**3.513**	**54.534**	**5.372**	**2.023**	**36.207**	**4.419**	**3.530**	**135.470**	**5.374**
214	**3.550**	**111.976**	**5.444**	**3.533**	**55.137**	**5.442**	**2.031**	**37.939**	**4.473**	**3.550**	**137.201**	**5.444**
215	**3.571**	**113.128**	**5.514**	**3.553**	**55.740**	**5.511**	**2.039**	**39.671**	**4.527**	**3.571**	**138.931**	**5.514**
216	**3.591**	**113.763**	**5.564**	**3.571**	**56.057**	**5.559**	**2.044**	**39.822**	**4.565**	**3.591**	**140.070**	**5.564**
217	**3.612**	**114.398**	**5.613**	**3.589**	**56.373**	**5.606**	**2.048**	**39.973**	**4.602**	**3.612**	**141.208**	**5.613**
218	**3.632**	**115.033**	**5.663**	**3.608**	**56.689**	**5.654**	**2.053**	**40.125**	**4.640**	**3.632**	**142.347**	**5.663**
219	**3.652**	**115.668**	**5.713**	**3.626**	**57.005**	**5.701**	**2.058**	**40.276**	**4.677**	**3.652**	**143.485**	**5.713**
220	**3.672**	**116.304**	**5.763**	**3.644**	**57.321**	**5.749**	**2.062**	**40.427**	**4.715**	**3.672**	**144.624**	**5.763**
221	**3.693**	**116.644**	**5.775**	**3.669**	**57.474**	**5.761**	**2.076**	**40.526**	**4.724**	**3.693**	**144.903**	**5.775**
222	**3.714**	**116.984**	**5.787**	**3.693**	**57.626**	**5.773**	**2.089**	**40.626**	**4.732**	**3.714**	**145.182**	**5.787**
223	**3.736**	**117.324**	**5.799**	**3.717**	**57.779**	**5.785**	**2.103**	**40.725**	**4.741**	**3.736**	**145.462**	**5.799**
224	**3.757**	**117.663**	**5.811**	**3.741**	**57.931**	**5.797**	**2.117**	**40.825**	**4.750**	**3.757**	**145.741**	**5.811**
225	**3.778**	**118.003**	**5.823**	**3.766**	**58.084**	**5.809**	**2.130**	**40.924**	**4.759**	**3.778**	**146.020**	**5.823**
226	**3.795**	**118.158**	**5.828**	**3.782**	**58.158**	**5.814**	**2.160**	**40.962**	**4.764**	**3.795**	**146.177**	**5.828**
227	**3.811**	**118.312**	**5.833**	**3.798**	**58.232**	**5.820**	**2.190**	**41.000**	**4.770**	**3.811**	**146.334**	**5.833**
228	**3.828**	**118.466**	**5.838**	**3.815**	**58.307**	**5.825**	**2.219**	**41.038**	**4.775**	**3.828**	**146.491**	**5.838**
229	**3.845**	**118.621**	**5.842**	**3.831**	**58.381**	**5.830**	**2.249**	**41.076**	**4.781**	**3.845**	**146.648**	**5.842**
230	**3.862**	**118.775**	**5.847**	**3.848**	**58.455**	**5.835**	**2.278**	**41.114**	**4.786**	**3.862**	**146.805**	**5.847**
231	**3.873**	**118.885**	**5.852**	**3.858**	**58.534**	**5.840**	**2.285**	**41.142**	**4.790**	**3.873**	**147.057**	**5.852**
232	**3.884**	**118.995**	**5.856**	**3.868**	**58.612**	**5.845**	**2.292**	**41.171**	**4.794**	**3.884**	**147.308**	**5.856**
233	**3.896**	**119.105**	**5.860**	**3.879**	**58.690**	**5.850**	**2.299**	**41.199**	**4.797**	**3.896**	**147.560**	**5.860**
234	**3.907**	**119.215**	**5.865**	**3.889**	**58.769**	**5.855**	**2.306**	**41.228**	**4.801**	**3.907**	**147.812**	**5.865**
235	**3.918**	**119.325**	**5.869**	**3.900**	**58.847**	**5.860**	**2.313**	**41.256**	**4.805**	**3.918**	**148.064**	**5.869**
236	**3.924**	**119.407**	**5.874**	**3.907**	**58.990**	**5.865**	**2.315**	**41.285**	**4.808**	**3.924**	**148.450**	**5.874**
237	**3.930**	**119.488**	**5.878**	**3.913**	**59.132**	**5.869**	**2.318**	**41.313**	**4.812**	**3.930**	**148.837**	**5.878**
238	**3.935**	**119.570**	**5.883**	**3.920**	**59.275**	**5.874**	**2.320**	**41.341**	**4.815**	**3.935**	**149.223**	**5.883**
239	**3.941**	**119.651**	**5.887**	**3.927**	**59.418**	**5.878**	**2.322**	**41.369**	**4.818**	**3.941**	**149.609**	**5.887**
240	**3.947**	**119.733**	**5.892**	**3.934**	**59.560**	**5.883**	**2.325**	**41.397**	**4.822**	**3.947**	**149.996**	**5.892**

Alternative Fast-Pass IM240 Standards
Corresponding to Composite Start-up Emission Standards in §85.2205(a)(2)(iv)

Light Duty Truck 1&2

	1982-1983			1984-1987			1988-1990			1991		
Sec	HC	CO	NOx	HC	CO	NOx	HC	CO	NOx	HC	CO	NOx
30	1.064	14.776	0.562	0.585	10.661	0.513	0.585	10.661	0.298	0.477	5.069	0.254
31	1.091	15.338	0.610	0.609	11.033	0.551	0.609	11.033	0.319	0.494	5.129	0.270
32	1.118	15.900	0.657	0.633	11.405	0.590	0.633	11.405	0.340	0.512	5.189	0.285
33	1.145	16.462	0.705	0.657	11.777	0.629	0.657	11.777	0.361	0.529	5.249	0.300
34	1.172	17.023	0.752	0.681	12.149	0.667	0.681	12.149	0.382	0.547	5.309	0.316
35	1.199	17.585	0.800	0.705	12.521	0.706	0.705	12.521	0.403	0.564	5.369	0.331
36	1.237	17.834	0.804	0.730	12.895	0.711	0.730	12.895	0.407	0.582	5.562	0.334
37	1.275	18.084	0.808	0.754	13.269	0.716	0.754	13.269	0.410	0.601	5.755	0.336
38	1.313	18.333	0.813	0.779	13.643	0.721	0.779	13.643	0.414	0.619	5.948	0.339
39	1.351	18.582	0.817	0.803	14.018	0.727	0.803	14.018	0.418	0.637	6.142	0.341
40	1.389	18.832	0.822	0.828	14.392	0.732	0.828	14.392	0.422	0.656	6.335	0.344
41	1.459	19.867	0.869	0.854	15.098	0.796	0.854	15.098	0.451	0.681	6.890	0.368
42	1.529	20.902	0.915	0.880	15.805	0.861	0.880	15.805	0.479	0.707	7.445	0.392
43	1.599	21.937	0.962	0.907	16.511	0.925	0.907	16.511	0.508	0.732	7.999	0.416
44	1.669	22.972	1.009	0.933	17.217	0.989	0.933	17.217	0.536	0.758	8.554	0.440
45	1.738	24.008	1.056	0.959	17.924	1.053	0.959	17.924	0.565	0.783	9.109	0.464
46	1.784	24.572	1.098	0.989	18.458	1.096	0.989	18.458	0.587	0.799	9.593	0.480
47	1.830	25.136	1.140	1.019	18.992	1.138	1.019	18.992	0.609	0.816	10.076	0.496
48	1.876	25.701	1.182	1.050	19.526	1.180	1.050	19.526	0.631	0.832	10.560	0.512
49	1.922	26.265	1.224	1.080	20.060	1.223	1.080	20.060	0.652	0.848	11.044	0.528
50	1.968	26.830	1.266	1.110	20.594	1.265	1.110	20.594	0.674	0.864	11.527	0.543
51	2.020	27.642	1.305	1.146	21.719	1.294	1.146	21.719	0.701	0.891	12.038	0.563
52	2.072	28.454	1.343	1.182	22.845	1.324	1.182	22.845	0.728	0.917	12.549	0.582
53	2.124	29.266	1.381	1.218	23.970	1.353	1.218	23.970	0.755	0.943	13.059	0.601
54	2.176	30.079	1.420	1.254	25.095	1.382	1.254	25.095	0.782	0.969	13.570	0.621
55	2.228	30.891	1.458	1.290	26.221	1.411	1.290	26.221	0.809	0.995	14.081	0.640
56	2.265	31.485	1.490	1.310	26.449	1.449	1.310	26.449	0.826	1.015	14.438	0.653
57	2.302	32.078	1.522	1.330	26.677	1.486	1.330	26.677	0.842	1.035	14.796	0.666
58	2.340	32.672	1.555	1.350	26.905	1.523	1.350	26.905	0.859	1.055	15.154	0.679
59	2.377	33.266	1.587	1.370	27.133	1.560	1.370	27.133	0.876	1.075	15.512	0.692
60	2.415	33.860	1.619	1.390	27.361	1.597	1.390	27.361	0.892	1.095	15.870	0.705
61	2.451	34.449	1.637	1.405	27.372	1.611	1.405	27.372	0.903	1.109	16.268	0.714
62	2.487	35.037	1.656	1.420	27.383	1.625	1.420	27.383	0.915	1.124	16.667	0.723
63	2.523	35.626	1.674	1.434	27.393	1.639	1.434	27.393	0.926	1.138	17.066	0.732
64	2.559	36.215	1.693	1.449	27.404	1.653	1.449	27.404	0.938	1.153	17.465	0.741
65	2.595	36.804	1.711	1.464	27.415	1.667	1.464	27.415	0.949	1.167	17.863	0.750
66	2.639	37.463	1.737	1.497	28.054	1.699	1.497	28.054	0.960	1.182	18.249	0.759
67	2.683	38.122	1.763	1.530	28.694	1.732	1.530	28.694	0.972	1.196	18.635	0.768
68	2.728	38.782	1.789	1.563	29.333	1.765	1.563	29.333	0.983	1.211	19.020	0.777

69	**2.772**	**39.441**	**1.815**	**1.596**	**29.972**	**1.797**	**1.596**	**29.972**	**0.994**	**1.225**	**19.406**	**0.786**
70	**2.817**	**40.100**	**1.841**	**1.629**	**30.612**	**1.830**	**1.629**	**30.612**	**1.005**	**1.239**	**19.792**	**0.795**
71	**2.859**	**40.631**	**1.862**	**1.650**	**31.097**	**1.854**	**1.650**	**31.097**	**1.016**	**1.255**	**19.906**	**0.805**
72	**2.901**	**41.161**	**1.884**	**1.672**	**31.583**	**1.878**	**1.672**	**31.583**	**1.028**	**1.271**	**20.020**	**0.815**
73	**2.943**	**41.692**	**1.906**	**1.694**	**32.068**	**1.902**	**1.694**	**32.068**	**1.039**	**1.287**	**20.134**	**0.825**
74	**2.985**	**42.222**	**1.928**	**1.715**	**32.554**	**1.925**	**1.715**	**32.554**	**1.051**	**1.303**	**20.248**	**0.835**
75	**3.027**	**42.753**	**1.950**	**1.737**	**33.039**	**1.949**	**1.737**	**33.039**	**1.062**	**1.318**	**20.362**	**0.845**
76	**3.061**	**43.694**	**1.978**	**1.760**	**33.193**	**1.977**	**1.760**	**33.193**	**1.074**	**1.331**	**20.782**	**0.859**
77	**3.096**	**44.636**	**2.007**	**1.782**	**33.347**	**2.005**	**1.782**	**33.347**	**1.085**	**1.344**	**21.202**	**0.874**
78	**3.130**	**45.577**	**2.035**	**1.805**	**33.501**	**2.033**	**1.805**	**33.501**	**1.096**	**1.357**	**21.623**	**0.888**
79	**3.165**	**46.519**	**2.063**	**1.828**	**33.655**	**2.061**	**1.828**	**33.655**	**1.108**	**1.370**	**22.043**	**0.902**
80	**3.200**	**47.461**	**2.092**	**1.851**	**33.809**	**2.089**	**1.851**	**33.809**	**1.119**	**1.382**	**22.463**	**0.916**
81	**3.237**	**47.831**	**2.111**	**1.872**	**34.035**	**2.111**	**1.872**	**34.035**	**1.131**	**1.407**	**22.571**	**0.925**
82	**3.275**	**48.201**	**2.130**	**1.894**	**34.261**	**2.132**	**1.894**	**34.261**	**1.144**	**1.431**	**22.678**	**0.934**
83	**3.313**	**48.571**	**2.149**	**1.915**	**34.488**	**2.154**	**1.915**	**34.488**	**1.156**	**1.455**	**22.786**	**0.942**
84	**3.351**	**48.941**	**2.168**	**1.937**	**34.714**	**2.175**	**1.937**	**34.714**	**1.169**	**1.480**	**22.894**	**0.951**
85	**3.389**	**49.311**	**2.187**	**1.958**	**34.941**	**2.197**	**1.958**	**34.941**	**1.181**	**1.504**	**23.001**	**0.960**
86	**3.432**	**49.503**	**2.189**	**1.973**	**35.115**	**2.200**	**1.973**	**35.115**	**1.182**	**1.531**	**23.112**	**0.961**
87	**3.475**	**49.694**	**2.192**	**1.988**	**35.289**	**2.203**	**1.988**	**35.289**	**1.182**	**1.558**	**23.223**	**0.963**
88	**3.518**	**49.886**	**2.194**	**2.002**	**35.463**	**2.206**	**2.002**	**35.463**	**1.183**	**1.586**	**23.334**	**0.964**
89	**3.562**	**50.077**	**2.197**	**2.017**	**35.637**	**2.209**	**2.017**	**35.637**	**1.184**	**1.613**	**23.445**	**0.966**
90	**3.605**	**50.269**	**2.199**	**2.032**	**35.811**	**2.212**	**2.032**	**35.811**	**1.185**	**1.640**	**23.556**	**0.967**
91	**3.645**	**50.447**	**2.200**	**2.044**	**35.968**	**2.213**	**2.044**	**35.968**	**1.186**	**1.654**	**23.558**	**0.968**
92	**3.686**	**50.626**	**2.201**	**2.056**	**36.125**	**2.214**	**2.056**	**36.125**	**1.187**	**1.668**	**23.560**	**0.968**
93	**3.727**	**50.805**	**2.202**	**2.068**	**36.282**	**2.215**	**2.068**	**36.282**	**1.188**	**1.682**	**23.562**	**0.968**
94	**3.767**	**50.984**	**2.203**	**2.081**	**36.440**	**2.216**	**2.081**	**36.440**	**1.189**	**1.696**	**23.564**	**0.969**
95	**3.808**	**51.162**	**2.204**	**2.093**	**36.597**	**2.217**	**2.093**	**36.597**	**1.190**	**1.710**	**23.567**	**0.969**
96	**3.853**	**51.779**	**2.212**	**2.111**	**36.968**	**2.227**	**2.111**	**36.968**	**1.195**	**1.727**	**23.924**	**0.978**
97	**3.898**	**52.395**	**2.219**	**2.129**	**37.339**	**2.236**	**2.129**	**37.339**	**1.201**	**1.744**	**24.282**	**0.987**
98	**3.943**	**53.012**	**2.227**	**2.147**	**37.710**	**2.245**	**2.147**	**37.710**	**1.207**	**1.762**	**24.639**	**0.996**
99	**3.988**	**53.628**	**2.234**	**2.165**	**38.081**	**2.254**	**2.165**	**38.081**	**1.213**	**1.779**	**24.997**	**1.004**
100	**4.033**	**54.245**	**2.242**	**2.183**	**38.453**	**2.263**	**2.183**	**38.453**	**1.218**	**1.796**	**25.355**	**1.013**
101	**4.081**	**55.131**	**2.322**	**2.221**	**40.429**	**2.342**	**2.221**	**40.429**	**1.259**	**1.819**	**25.871**	**1.045**
102	**4.128**	**56.016**	**2.403**	**2.258**	**42.405**	**2.420**	**2.258**	**42.405**	**1.299**	**1.842**	**26.387**	**1.076**
103	**4.175**	**56.902**	**2.484**	**2.295**	**44.382**	**2.498**	**2.295**	**44.382**	**1.340**	**1.865**	**26.903**	**1.107**
104	**4.223**	**57.788**	**2.565**	**2.333**	**46.358**	**2.576**	**2.333**	**46.358**	**1.380**	**1.887**	**27.419**	**1.139**
105	**4.270**	**58.674**	**2.646**	**2.370**	**48.335**	**2.654**	**2.370**	**48.335**	**1.421**	**1.910**	**27.935**	**1.170**
106	**4.300**	**59.222**	**2.721**	**2.404**	**49.060**	**2.740**	**2.404**	**49.060**	**1.458**	**1.936**	**28.221**	**1.201**
107	**4.331**	**59.771**	**2.797**	**2.437**	**49.785**	**2.826**	**2.437**	**49.785**	**1.495**	**1.962**	**28.506**	**1.232**
108	**4.361**	**60.319**	**2.872**	**2.471**	**50.511**	**2.912**	**2.471**	**50.511**	**1.531**	**1.988**	**28.792**	**1.263**
109	**4.391**	**60.868**	**2.948**	**2.504**	**51.236**	**2.998**	**2.504**	**51.236**	**1.568**	**2.014**	**29.077**	**1.294**
110	**4.421**	**61.416**	**3.023**	**2.538**	**51.962**	**3.084**	**2.538**	**51.962**	**1.605**	**2.040**	**29.363**	**1.325**
111	**4.449**	**61.935**	**3.038**	**2.560**	**52.113**	**3.101**	**2.560**	**52.113**	**1.615**	**2.057**	**29.405**	**1.332**
112	**4.476**	**62.455**	**3.053**	**2.582**	**52.265**	**3.118**	**2.582**	**52.265**	**1.624**	**2.074**	**29.447**	**1.338**
113	**4.503**	**62.974**	**3.067**	**2.604**	**52.417**	**3.136**	**2.604**	**52.417**	**1.634**	**2.090**	**29.489**	**1.344**

114	**4.531**	**63.493**	**3.082**	**2.625**	**52.569**	**3.153**	**2.625**	**52.569**	**1.644**	**2.107**	**29.531**	**1.350**
115	**4.558**	**64.013**	**3.097**	**2.647**	**52.721**	**3.170**	**2.647**	**52.721**	**1.653**	**2.124**	**29.573**	**1.357**
116	**4.600**	**64.559**	**3.099**	**2.673**	**52.723**	**3.173**	**2.673**	**52.723**	**1.656**	**2.152**	**29.865**	**1.359**
117	**4.642**	**65.105**	**3.102**	**2.698**	**52.724**	**3.175**	**2.698**	**52.724**	**1.658**	**2.179**	**30.157**	**1.361**
118	**4.684**	**65.651**	**3.105**	**2.723**	**52.726**	**3.178**	**2.723**	**52.726**	**1.661**	**2.207**	**30.449**	**1.363**
119	**4.726**	**66.197**	**3.108**	**2.749**	**52.728**	**3.181**	**2.749**	**52.728**	**1.663**	**2.234**	**30.741**	**1.365**
120	**4.768**	**66.743**	**3.111**	**2.774**	**52.729**	**3.184**	**2.774**	**52.729**	**1.666**	**2.262**	**31.033**	**1.368**
121	**4.804**	**67.600**	**3.134**	**2.799**	**53.168**	**3.206**	**2.799**	**53.168**	**1.684**	**2.276**	**31.230**	**1.383**
122	**4.840**	**68.458**	**3.156**	**2.824**	**53.606**	**3.229**	**2.824**	**53.606**	**1.703**	**2.290**	**31.428**	**1.399**
123	**4.876**	**69.315**	**3.179**	**2.850**	**54.044**	**3.251**	**2.850**	**54.044**	**1.722**	**2.304**	**31.625**	**1.415**
124	**4.911**	**70.173**	**3.202**	**2.875**	**54.483**	**3.274**	**2.875**	**54.483**	**1.741**	**2.318**	**31.823**	**1.431**
125	**4.947**	**71.030**	**3.224**	**2.900**	**54.921**	**3.296**	**2.900**	**54.921**	**1.759**	**2.332**	**32.020**	**1.446**
126	**4.983**	**71.729**	**3.241**	**2.920**	**55.078**	**3.310**	**2.920**	**55.078**	**1.770**	**2.355**	**32.099**	**1.453**
127	**5.019**	**72.427**	**3.257**	**2.941**	**55.236**	**3.323**	**2.941**	**55.236**	**1.780**	**2.377**	**32.178**	**1.460**
128	**5.055**	**73.126**	**3.274**	**2.961**	**55.393**	**3.337**	**2.961**	**55.393**	**1.790**	**2.399**	**32.256**	**1.468**
129	**5.091**	**73.825**	**3.290**	**2.981**	**55.551**	**3.350**	**2.981**	**55.551**	**1.800**	**2.422**	**32.335**	**1.475**
130	**5.126**	**74.523**	**3.307**	**3.001**	**55.708**	**3.364**	**3.001**	**55.708**	**1.811**	**2.444**	**32.413**	**1.482**
131	**5.178**	**75.331**	**3.311**	**3.027**	**55.921**	**3.370**	**3.027**	**55.921**	**1.813**	**2.464**	**32.638**	**1.484**
132	**5.230**	**76.139**	**3.316**	**3.052**	**56.134**	**3.376**	**3.052**	**56.134**	**1.816**	**2.485**	**32.862**	**1.487**
133	**5.282**	**76.947**	**3.321**	**3.078**	**56.346**	**3.382**	**3.078**	**56.346**	**1.819**	**2.505**	**33.086**	**1.490**
134	**5.334**	**77.755**	**3.326**	**3.103**	**56.559**	**3.388**	**3.103**	**56.559**	**1.822**	**2.525**	**33.310**	**1.492**
135	**5.386**	**78.563**	**3.331**	**3.129**	**56.771**	**3.394**	**3.129**	**56.771**	**1.825**	**2.545**	**33.534**	**1.495**
136	**5.468**	**79.372**	**3.365**	**3.167**	**57.854**	**3.432**	**3.167**	**57.854**	**1.851**	**2.573**	**34.147**	**1.520**
137	**5.549**	**80.181**	**3.398**	**3.206**	**58.937**	**3.469**	**3.206**	**58.937**	**1.877**	**2.600**	**34.760**	**1.546**
138	**5.630**	**80.990**	**3.431**	**3.244**	**60.020**	**3.507**	**3.244**	**60.020**	**1.903**	**2.628**	**35.373**	**1.571**
139	**5.712**	**81.798**	**3.464**	**3.283**	**61.102**	**3.544**	**3.283**	**61.102**	**1.929**	**2.655**	**35.985**	**1.596**
140	**5.793**	**82.607**	**3.498**	**3.322**	**62.185**	**3.582**	**3.322**	**62.185**	**1.955**	**2.682**	**36.598**	**1.622**
141	**5.825**	**83.486**	**3.536**	**3.342**	**62.366**	**3.639**	**3.342**	**62.366**	**1.977**	**2.702**	**36.880**	**1.639**
142	**5.856**	**84.365**	**3.575**	**3.363**	**62.548**	**3.697**	**3.363**	**62.548**	**1.999**	**2.722**	**37.162**	**1.656**
143	**5.888**	**85.245**	**3.613**	**3.383**	**62.729**	**3.754**	**3.383**	**62.729**	**2.021**	**2.742**	**37.444**	**1.673**
144	**5.920**	**86.124**	**3.652**	**3.404**	**62.910**	**3.811**	**3.404**	**62.910**	**2.043**	**2.762**	**37.727**	**1.691**
145	**5.951**	**87.003**	**3.690**	**3.425**	**63.091**	**3.869**	**3.425**	**63.091**	**2.065**	**2.782**	**38.009**	**1.708**
146	**5.975**	**87.915**	**3.718**	**3.453**	**63.539**	**3.892**	**3.453**	**63.539**	**2.074**	**2.797**	**38.632**	**1.717**
147	**5.998**	**88.827**	**3.745**	**3.482**	**63.987**	**3.916**	**3.482**	**63.987**	**2.082**	**2.811**	**39.255**	**1.726**
148	**6.022**	**89.739**	**3.772**	**3.510**	**64.435**	**3.939**	**3.510**	**64.435**	**2.090**	**2.825**	**39.878**	**1.735**
149	**6.046**	**90.652**	**3.800**	**3.539**	**64.883**	**3.963**	**3.539**	**64.883**	**2.098**	**2.839**	**40.501**	**1.743**
150	**6.069**	**91.564**	**3.827**	**3.568**	**65.331**	**3.986**	**3.568**	**65.331**	**2.106**	**2.853**	**41.124**	**1.752**
151	**6.099**	**92.475**	**3.852**	**3.595**	**65.704**	**4.000**	**3.595**	**65.704**	**2.117**	**2.868**	**41.450**	**1.765**
152	**6.129**	**93.387**	**3.877**	**3.623**	**66.077**	**4.014**	**3.623**	**66.077**	**2.129**	**2.883**	**41.776**	**1.778**
153	**6.159**	**94.298**	**3.901**	**3.650**	**66.450**	**4.029**	**3.650**	**66.450**	**2.141**	**2.898**	**42.102**	**1.791**
154	**6.189**	**95.209**	**3.926**	**3.677**	**66.823**	**4.043**	**3.677**	**66.823**	**2.152**	**2.913**	**42.428**	**1.803**
155	**6.219**	**96.121**	**3.951**	**3.705**	**67.197**	**4.057**	**3.705**	**67.197**	**2.164**	**2.927**	**42.754**	**1.816**
156	**6.313**	**97.599**	**4.030**	**3.767**	**69.206**	**4.117**	**3.767**	**69.206**	**2.205**	**2.969**	**44.233**	**1.849**
157	**6.407**	**99.077**	**4.110**	**3.829**	**71.215**	**4.176**	**3.829**	**71.215**	**2.247**	**3.011**	**45.712**	**1.882**
158	**6.501**	**100.555**	**4.190**	**3.891**	**73.225**	**4.236**	**3.891**	**73.225**	**2.289**	**3.053**	**47.191**	**1.915**

159	6.595	102.033	4.269	3.953	75.234	4.295	3.953	75.234	2.330	3.095	48.670	1.948
160	6.689	103.511	4.349	4.015	77.243	4.355	4.015	77.243	2.372	3.136	50.149	1.981
161	7.010	107.552	4.542	4.078	79.985	4.551	4.078	79.985	2.472	3.182	51.569	2.071
162	7.331	111.593	4.736	4.142	82.727	4.747	4.142	82.727	2.571	3.227	52.988	2.162
163	7.652	115.634	4.930	4.205	85.469	4.943	4.205	85.469	2.671	3.272	54.408	2.252
164	7.972	119.676	5.123	4.268	88.211	5.139	4.268	88.211	2.770	3.318	55.828	2.343
165	8.293	123.717	5.317	4.332	90.953	5.335	4.332	90.953	2.870	3.363	57.247	2.434
166	8.576	125.252	5.496	4.380	93.266	5.516	4.380	93.266	2.961	3.410	58.958	2.509
167	8.859	126.786	5.676	4.428	95.579	5.696	4.428	95.579	3.053	3.458	60.670	2.584
168	9.142	128.321	5.855	4.477	97.892	5.876	4.477	97.892	3.144	3.505	62.381	2.659
169	9.425	129.855	6.034	4.525	100.205	6.056	4.525	100.205	3.235	3.552	64.092	2.735
170	9.708	131.390	6.213	4.573	102.517	6.237	4.573	102.517	3.327	3.600	65.804	2.810
171	9.788	132.095	6.318	4.618	103.813	6.345	4.618	103.813	3.373	3.644	66.939	2.863
172	9.868	132.801	6.422	4.664	105.109	6.452	4.664	105.109	3.420	3.688	68.075	2.916
173	9.948	133.506	6.527	4.709	106.404	6.560	4.709	106.404	3.467	3.732	69.210	2.969
174	10.028	134.211	6.632	4.754	107.700	6.668	4.754	107.700	3.513	3.776	70.345	3.022
175	10.107	134.917	6.736	4.799	108.995	6.776	4.799	108.995	3.560	3.821	71.481	3.075
176	10.174	137.703	6.876	4.858	110.733	6.910	4.858	110.733	3.626	3.856	73.077	3.130
177	10.242	140.490	7.016	4.917	112.471	7.045	4.917	112.471	3.692	3.891	74.674	3.185
178	10.309	143.276	7.155	4.977	114.209	7.179	4.977	114.209	3.758	3.927	76.271	3.240
179	10.376	146.063	7.295	5.036	115.946	7.313	5.036	115.946	3.824	3.962	77.867	3.295
180	10.443	148.849	7.435	5.095	117.684	7.447	5.095	117.684	3.889	3.997	79.464	3.350
181	10.506	152.900	7.603	5.158	119.775	7.621	5.158	119.775	3.979	4.024	81.282	3.430
182	10.570	156.950	7.772	5.221	121.866	7.795	5.221	121.866	4.069	4.050	83.100	3.509
183	10.634	161.001	7.941	5.284	123.956	7.969	5.284	123.956	4.159	4.077	84.919	3.589
184	10.698	165.051	8.110	5.347	126.047	8.143	5.347	126.047	4.248	4.104	86.737	3.668
185	10.761	169.102	8.279	5.411	128.138	8.318	5.411	128.138	4.338	4.131	88.555	3.748
186	10.836	171.850	8.477	5.428	129.673	8.499	5.428	129.673	4.443	4.154	90.333	3.841
187	10.911	174.598	8.675	5.446	131.209	8.681	5.446	131.209	4.547	4.178	92.110	3.934
188	10.986	177.345	8.873	5.463	132.745	8.862	5.463	132.745	4.652	4.202	93.888	4.026
189	11.061	180.093	9.071	5.481	134.281	9.043	5.481	134.281	4.756	4.225	95.665	4.119
190	11.136	182.841	9.269	5.499	135.816	9.225	5.499	135.816	4.861	4.249	97.442	4.212
191	11.307	184.591	9.422	5.561	137.198	9.386	5.561	137.198	4.932	4.285	98.856	4.274
192	11.477	186.341	9.576	5.623	138.580	9.547	5.623	138.580	5.003	4.321	100.271	4.336
193	11.648	188.091	9.730	5.686	139.961	9.708	5.686	139.961	5.074	4.357	101.685	4.398
194	11.819	189.841	9.884	5.748	141.343	9.869	5.748	141.343	5.146	4.393	103.099	4.459
195	11.990	191.591	10.038	5.810	142.724	10.030	5.810	142.724	5.217	4.430	104.513	4.521
196	12.067	194.037	10.193	5.828	144.052	10.188	5.828	144.052	5.301	4.460	106.134	4.589
197	12.144	196.482	10.348	5.845	145.381	10.346	5.845	145.381	5.385	4.490	107.755	4.658
198	12.221	198.927	10.503	5.863	146.709	10.504	5.863	146.709	5.469	4.520	109.376	4.726
199	12.298	201.373	10.658	5.880	148.037	10.662	5.880	148.037	5.553	4.550	110.997	4.795
200	12.376	203.818	10.813	5.898	149.365	10.820	5.898	149.365	5.637	4.580	112.617	4.863
201	12.463	204.868	10.912	5.942	150.214	10.948	5.942	150.214	5.692	4.623	113.207	4.906
202	12.551	205.918	11.012	5.986	151.063	11.075	5.986	151.063	5.746	4.666	113.796	4.949
203	12.639	206.967	11.111	6.029	151.912	11.203	6.029	151.912	5.801	4.709	114.385	4.993

204	12.726	208.017	11.211	6.073	152.760	11.330	6.073	152.760	5.856	4.752	114.974	5.036
205	12.814	209.067	11.310	6.117	153.609	11.458	6.117	153.609	5.911	4.795	115.563	5.079
206	12.891	211.915	11.381	6.174	154.888	11.530	6.174	154.888	5.951	4.848	116.847	5.119
207	12.969	214.764	11.452	6.231	156.166	11.601	6.231	156.166	5.990	4.901	118.131	5.160
208	13.046	217.612	11.523	6.288	157.445	11.673	6.288	157.445	6.030	4.955	119.415	5.201
209	13.124	220.460	11.594	6.345	158.724	11.745	6.345	158.724	6.070	5.008	120.699	5.241
210	13.201	223.309	11.665	6.401	160.002	11.817	6.401	160.002	6.110	5.061	121.983	5.282
211	13.243	226.365	11.862	6.451	161.606	11.984	6.451	161.606	6.194	5.090	123.498	5.355
212	13.285	229.421	12.060	6.500	163.210	12.152	6.500	163.210	6.278	5.119	125.012	5.429
213	13.327	232.478	12.257	6.550	164.814	12.319	6.550	164.814	6.362	5.147	126.526	5.502
214	13.370	235.534	12.455	6.599	166.418	12.486	6.599	166.418	6.446	5.176	128.040	5.576
215	13.412	238.591	12.653	6.649	168.022	12.653	6.649	168.022	6.530	5.204	129.554	5.649
216	13.470	240.891	12.778	6.693	168.948	12.780	6.693	168.948	6.585	5.240	130.345	5.695
217	13.528	243.191	12.904	6.737	169.874	12.906	6.737	169.874	6.640	5.275	131.136	5.741
218	13.586	245.492	13.030	6.782	170.800	13.032	6.782	170.800	6.695	5.310	131.928	5.787
219	13.645	247.792	13.156	6.826	171.726	13.159	6.826	171.726	6.750	5.345	132.719	5.833
220	13.703	250.092	13.282	6.870	172.653	13.285	6.870	172.653	6.804	5.380	133.510	5.879
221	13.896	250.710	13.307	6.946	173.200	13.314	6.946	173.200	6.818	5.436	133.899	5.888
222	14.088	251.329	13.332	7.022	173.748	13.343	7.022	173.748	6.831	5.492	134.287	5.896
223	14.281	251.947	13.358	7.098	174.295	13.371	7.098	174.295	6.844	5.548	134.676	5.905
224	14.474	252.565	13.383	7.173	174.843	13.400	7.173	174.843	6.857	5.604	135.064	5.913
225	14.667	253.184	13.409	7.249	175.391	13.429	7.249	175.391	6.870	5.660	135.453	5.922
226	14.845	253.888	13.422	7.334	175.611	13.440	7.334	175.611	6.877	5.699	135.633	5.927
227	15.023	254.593	13.436	7.419	175.831	13.452	7.419	175.831	6.884	5.738	135.814	5.931
228	15.201	255.297	13.450	7.504	176.051	13.464	7.504	176.051	6.891	5.776	135.995	5.936
229	15.379	256.002	13.464	7.589	176.271	13.475	7.589	176.271	6.897	5.815	136.176	5.941
230	15.557	256.706	13.478	7.674	176.491	13.487	7.674	176.491	6.904	5.854	136.356	5.946
231	15.658	257.286	13.488	7.710	176.612	13.498	7.710	176.612	6.910	5.875	136.581	5.951
232	15.759	257.866	13.499	7.746	176.732	13.508	7.746	176.732	6.916	5.897	136.806	5.956
233	15.861	258.445	13.510	7.782	176.853	13.519	7.782	176.853	6.922	5.918	137.031	5.962
234	15.962	259.025	13.521	7.818	176.974	13.530	7.818	176.974	6.928	5.940	137.256	5.967
235	16.063	259.605	13.531	7.853	177.095	13.540	7.853	177.095	6.934	5.961	137.482	5.972
236	16.104	259.940	13.543	7.867	177.463	13.551	7.867	177.463	6.940	5.977	137.680	5.978
237	16.144	260.276	13.554	7.881	177.830	13.561	7.881	177.830	6.946	5.994	137.879	5.983
238	16.185	260.612	13.566	7.894	178.198	13.572	7.894	178.198	6.951	6.010	138.078	5.989
239	16.225	260.947	13.577	7.908	178.566	13.582	7.908	178.566	6.957	6.026	138.277	5.994
240	16.265	261.283	13.589	7.922	178.933	13.592	7.922	178.933	6.962	6.042	138.476	6.000

Alternative Fast-Pass IM240 Standards
Corresponding to Composite Start-up Emission Standards in §85.2205(a)(2)(vi)

Light Duty Truck 3&4

	1982-1983			1984-1987			1988-1990			1991		
Sec	HC	CO	NOx	HC	CO	NOx	HC	CO	NOx	HC	CO	NOx
30	1.064	14.776	0.513	0.585	10.661	0.513	0.585	10.661	0.436	0.477	5.069	0.395
31	1.091	15.338	0.551	0.609	11.033	0.551	0.609	11.033	0.463	0.494	5.129	0.420
32	1.118	15.900	0.590	0.633	11.405	0.590	0.633	11.405	0.490	0.512	5.189	0.445
33	1.145	16.462	0.629	0.657	11.777	0.629	0.657	11.777	0.517	0.529	5.249	0.470
34	1.172	17.023	0.667	0.681	12.149	0.667	0.681	12.149	0.544	0.547	5.309	0.495
35	1.199	17.585	0.706	0.705	12.521	0.706	0.705	12.521	0.572	0.564	5.369	0.520
36	1.237	17.834	0.711	0.730	12.895	0.711	0.730	12.895	0.576	0.582	5.562	0.524
37	1.275	18.084	0.716	0.754	13.269	0.716	0.754	13.269	0.580	0.601	5.755	0.527
38	1.313	18.333	0.721	0.779	13.643	0.721	0.779	13.643	0.584	0.619	5.948	0.531
39	1.351	18.582	0.727	0.803	14.018	0.727	0.803	14.018	0.588	0.637	6.142	0.535
40	1.389	18.832	0.732	0.828	14.392	0.732	0.828	14.392	0.592	0.656	6.335	0.539
41	1.459	19.867	0.796	0.854	15.098	0.796	0.854	15.098	0.636	0.681	6.890	0.578
42	1.529	20.902	0.861	0.880	15.805	0.861	0.880	15.805	0.681	0.707	7.445	0.617
43	1.599	21.937	0.925	0.907	16.511	0.925	0.907	16.511	0.726	0.732	7.999	0.657
44	1.669	22.972	0.989	0.933	17.217	0.989	0.933	17.217	0.771	0.758	8.554	0.696
45	1.738	24.008	1.053	0.959	17.924	1.053	0.959	17.924	0.815	0.783	9.109	0.735
46	1.784	24.572	1.096	0.989	18.458	1.096	0.989	18.458	0.840	0.799	9.593	0.760
47	1.830	25.136	1.138	1.019	18.992	1.138	1.019	18.992	0.866	0.816	10.076	0.785
48	1.876	25.701	1.180	1.050	19.526	1.180	1.050	19.526	0.891	0.832	10.560	0.810
49	1.922	26.265	1.223	1.080	20.060	1.223	1.080	20.060	0.916	0.848	11.044	0.835
50	1.968	26.830	1.265	1.110	20.594	1.265	1.110	20.594	0.941	0.864	11.527	0.860
51	2.020	27.642	1.294	1.146	21.719	1.294	1.146	21.719	0.978	0.891	12.038	0.893
52	2.072	28.454	1.324	1.182	22.845	1.324	1.182	22.845	1.016	0.917	12.549	0.926
53	2.124	29.266	1.353	1.218	23.970	1.353	1.218	23.970	1.053	0.943	13.059	0.959
54	2.176	30.079	1.382	1.254	25.095	1.382	1.254	25.095	1.090	0.969	13.570	0.992
55	2.228	30.891	1.411	1.290	26.221	1.411	1.290	26.221	1.128	0.995	14.081	1.026
56	2.265	31.485	1.449	1.310	26.449	1.449	1.310	26.449	1.160	1.015	14.438	1.051
57	2.302	32.078	1.486	1.330	26.677	1.486	1.330	26.677	1.192	1.035	14.796	1.077
58	2.340	32.672	1.523	1.350	26.905	1.523	1.350	26.905	1.224	1.055	15.154	1.103
59	2.377	33.266	1.560	1.370	27.133	1.560	1.370	27.133	1.256	1.075	15.512	1.129
60	2.415	33.860	1.597	1.390	27.361	1.597	1.390	27.361	1.288	1.095	15.870	1.155
61	2.451	34.487	1.611	1.405	27.372	1.611	1.405	27.372	1.301	1.109	16.268	1.166
62	2.487	35.113	1.625	1.420	27.383	1.625	1.420	27.383	1.313	1.124	16.667	1.177
63	2.523	35.740	1.639	1.434	27.393	1.639	1.434	27.393	1.326	1.138	17.066	1.188
64	2.559	36.367	1.653	1.449	27.404	1.653	1.449	27.404	1.338	1.153	17.465	1.200
65	2.595	36.994	1.667	1.464	27.415	1.667	1.464	27.415	1.351	1.167	17.863	1.211
66	2.639	37.728	1.699	1.497	28.054	1.699	1.497	28.054	1.366	1.182	18.249	1.230
67	2.683	38.462	1.732	1.530	28.694	1.732	1.530	28.694	1.382	1.196	18.635	1.250
68	2.728	39.197	1.765	1.563	29.333	1.765	1.563	29.333	1.397	1.211	19.020	1.269

69	2.772	39.931	1.797	1.596	29.972	1.797	1.596	29.972	1.412	1.225	19.406	1.289
70	2.817	40.666	1.830	1.629	30.612	1.830	1.629	30.612	1.427	1.239	19.792	1.308
71	2.859	41.083	1.854	1.650	31.097	1.854	1.650	31.097	1.443	1.255	19.906	1.321
72	2.901	41.500	1.878	1.672	31.583	1.878	1.672	31.583	1.459	1.271	20.020	1.334
73	2.943	41.918	1.902	1.694	32.068	1.902	1.694	32.068	1.475	1.287	20.134	1.347
74	2.985	42.335	1.925	1.715	32.554	1.925	1.715	32.554	1.491	1.303	20.248	1.361
75	3.027	42.753	1.949	1.737	33.039	1.949	1.737	33.039	1.507	1.318	20.362	1.374
76	3.061	43.705	1.977	1.760	33.193	1.977	1.760	33.193	1.528	1.331	20.782	1.391
77	3.096	44.657	2.005	1.782	33.347	2.005	1.782	33.347	1.550	1.344	21.202	1.409
78	3.130	45.609	2.033	1.805	33.501	2.033	1.805	33.501	1.571	1.357	21.623	1.426
79	3.165	46.562	2.061	1.828	33.655	2.061	1.828	33.655	1.593	1.370	22.043	1.444
80	3.200	47.514	2.089	1.851	33.809	2.089	1.851	33.809	1.615	1.382	22.463	1.461
81	3.237	47.873	2.111	1.872	34.035	2.111	1.872	34.035	1.623	1.407	22.571	1.475
82	3.275	48.233	2.132	1.894	34.261	2.132	1.894	34.261	1.632	1.431	22.678	1.489
83	3.313	48.592	2.154	1.915	34.488	2.154	1.915	34.488	1.640	1.455	22.786	1.503
84	3.351	48.952	2.175	1.937	34.714	2.175	1.937	34.714	1.648	1.480	22.894	1.517
85	3.389	49.311	2.197	1.958	34.941	2.197	1.958	34.941	1.657	1.504	23.001	1.531
86	3.432	49.503	2.200	1.973	35.115	2.200	1.973	35.115	1.659	1.531	23.112	1.531
87	3.475	49.694	2.203	1.988	35.289	2.203	1.988	35.289	1.661	1.558	23.223	1.532
88	3.518	49.886	2.206	2.002	35.463	2.206	2.002	35.463	1.663	1.586	23.334	1.533
89	3.562	50.077	2.209	2.017	35.637	2.209	2.017	35.637	1.665	1.613	23.445	1.533
90	3.605	50.269	2.212	2.032	35.811	2.212	2.032	35.811	1.667	1.640	23.556	1.534
91	3.645	50.447	2.213	2.044	35.968	2.213	2.044	35.968	1.668	1.654	23.558	1.534
92	3.686	50.626	2.214	2.056	36.125	2.214	2.056	36.125	1.669	1.668	23.560	1.534
93	3.727	50.805	2.215	2.068	36.282	2.215	2.068	36.282	1.671	1.682	23.562	1.535
94	3.767	50.984	2.216	2.081	36.440	2.216	2.081	36.440	1.672	1.696	23.564	1.535
95	3.808	51.162	2.217	2.093	36.597	2.217	2.093	36.597	1.674	1.710	23.567	1.535
96	3.853	51.779	2.227	2.111	36.968	2.227	2.111	36.968	1.680	1.727	23.924	1.547
97	3.898	52.395	2.236	2.129	37.339	2.236	2.129	37.339	1.686	1.744	24.282	1.558
98	3.943	53.012	2.245	2.147	37.710	2.245	2.147	37.710	1.692	1.762	24.639	1.570
99	3.988	53.628	2.254	2.165	38.081	2.254	2.165	38.081	1.698	1.779	24.997	1.581
100	4.033	54.245	2.263	2.183	38.453	2.263	2.183	38.453	1.704	1.796	25.355	1.593
101	4.081	55.131	2.342	2.221	40.429	2.342	2.221	40.429	1.779	1.819	25.871	1.636
102	4.128	56.016	2.420	2.258	42.405	2.420	2.258	42.405	1.854	1.842	26.387	1.678
103	4.175	56.902	2.498	2.295	44.382	2.498	2.295	44.382	1.928	1.865	26.903	1.721
104	4.223	57.788	2.576	2.333	46.358	2.576	2.333	46.358	2.003	1.887	27.419	1.764
105	4.270	58.674	2.654	2.370	48.335	2.654	2.370	48.335	2.078	1.910	27.935	1.807
106	4.300	59.222	2.740	2.404	49.060	2.740	2.404	49.060	2.132	1.936	28.221	1.864
107	4.331	59.771	2.826	2.437	49.785	2.826	2.437	49.785	2.187	1.962	28.506	1.921
108	4.361	60.319	2.912	2.471	50.511	2.912	2.471	50.511	2.241	1.988	28.792	1.978
109	4.391	60.868	2.998	2.504	51.236	2.998	2.504	51.236	2.296	2.014	29.077	2.035
110	4.421	61.416	3.084	2.538	51.962	3.084	2.538	51.962	2.350	2.040	29.363	2.092
111	4.449	61.935	3.101	2.560	52.113	3.101	2.560	52.113	2.365	2.057	29.405	2.107
112	4.476	62.455	3.118	2.582	52.265	3.118	2.582	52.265	2.381	2.074	29.447	2.121
113	4.503	62.974	3.136	2.604	52.417	3.136	2.604	52.417	2.396	2.090	29.489	2.135

114	**4.531**	**63.493**	**3.153**	**2.625**	**52.569**	**3.153**	**2.625**	**52.569**	**2.411**	**2.107**	**29.531**	**2.149**
115	**4.558**	**64.013**	**3.170**	**2.647**	**52.721**	**3.170**	**2.647**	**52.721**	**2.426**	**2.124**	**29.573**	**2.163**
116	**4.600**	**64.559**	**3.173**	**2.673**	**52.723**	**3.173**	**2.673**	**52.723**	**2.430**	**2.152**	**29.865**	**2.166**
117	**4.642**	**65.105**	**3.175**	**2.698**	**52.724**	**3.175**	**2.698**	**52.724**	**2.433**	**2.179**	**30.157**	**2.169**
118	**4.684**	**65.651**	**3.178**	**2.723**	**52.726**	**3.178**	**2.723**	**52.726**	**2.437**	**2.207**	**30.449**	**2.173**
119	**4.726**	**66.197**	**3.181**	**2.749**	**52.728**	**3.181**	**2.749**	**52.728**	**2.441**	**2.234**	**30.741**	**2.176**
120	**4.768**	**66.743**	**3.184**	**2.774**	**52.729**	**3.184**	**2.774**	**52.729**	**2.445**	**2.262**	**31.033**	**2.179**
121	**4.804**	**67.600**	**3.206**	**2.799**	**53.168**	**3.206**	**2.799**	**53.168**	**2.467**	**2.276**	**31.230**	**2.200**
122	**4.840**	**68.458**	**3.229**	**2.824**	**53.606**	**3.229**	**2.824**	**53.606**	**2.489**	**2.290**	**31.428**	**2.222**
123	**4.876**	**69.315**	**3.251**	**2.850**	**54.044**	**3.251**	**2.850**	**54.044**	**2.512**	**2.304**	**31.625**	**2.243**
124	**4.911**	**70.173**	**3.274**	**2.875**	**54.483**	**3.274**	**2.875**	**54.483**	**2.534**	**2.318**	**31.823**	**2.265**
125	**4.947**	**71.030**	**3.296**	**2.900**	**54.921**	**3.296**	**2.900**	**54.921**	**2.557**	**2.332**	**32.020**	**2.286**
126	**4.983**	**71.729**	**3.310**	**2.920**	**55.078**	**3.310**	**2.920**	**55.078**	**2.569**	**2.355**	**32.099**	**2.297**
127	**5.019**	**72.427**	**3.323**	**2.941**	**55.236**	**3.323**	**2.941**	**55.236**	**2.580**	**2.377**	**32.178**	**2.307**
128	**5.055**	**73.126**	**3.337**	**2.961**	**55.393**	**3.337**	**2.961**	**55.393**	**2.592**	**2.399**	**32.256**	**2.318**
129	**5.091**	**73.825**	**3.350**	**2.981**	**55.551**	**3.350**	**2.981**	**55.551**	**2.604**	**2.422**	**32.335**	**2.329**
130	**5.126**	**74.523**	**3.364**	**3.001**	**55.708**	**3.364**	**3.001**	**55.708**	**2.616**	**2.444**	**32.413**	**2.339**
131	**5.178**	**75.331**	**3.370**	**3.027**	**55.921**	**3.370**	**3.027**	**55.921**	**2.619**	**2.464**	**32.638**	**2.343**
132	**5.230**	**76.139**	**3.376**	**3.052**	**56.134**	**3.376**	**3.052**	**56.134**	**2.623**	**2.485**	**32.862**	**2.347**
133	**5.282**	**76.947**	**3.382**	**3.078**	**56.346**	**3.382**	**3.078**	**56.346**	**2.627**	**2.505**	**33.086**	**2.350**
134	**5.334**	**77.755**	**3.388**	**3.103**	**56.559**	**3.388**	**3.103**	**56.559**	**2.630**	**2.525**	**33.310**	**2.354**
135	**5.386**	**78.563**	**3.394**	**3.129**	**56.771**	**3.394**	**3.129**	**56.771**	**2.634**	**2.545**	**33.534**	**2.358**
136	**5.468**	**79.372**	**3.432**	**3.167**	**57.854**	**3.432**	**3.167**	**57.854**	**2.672**	**2.573**	**34.147**	**2.395**
137	**5.549**	**80.181**	**3.469**	**3.206**	**58.937**	**3.469**	**3.206**	**58.937**	**2.711**	**2.600**	**34.760**	**2.431**
138	**5.630**	**80.990**	**3.507**	**3.244**	**60.020**	**3.507**	**3.244**	**60.020**	**2.749**	**2.628**	**35.373**	**2.468**
139	**5.712**	**81.798**	**3.544**	**3.283**	**61.102**	**3.544**	**3.283**	**61.102**	**2.787**	**2.655**	**35.985**	**2.505**
140	**5.793**	**82.607**	**3.582**	**3.322**	**62.185**	**3.582**	**3.322**	**62.185**	**2.826**	**2.682**	**36.598**	**2.542**
141	**5.825**	**83.486**	**3.639**	**3.342**	**62.366**	**3.639**	**3.342**	**62.366**	**2.851**	**2.702**	**36.880**	**2.574**
142	**5.856**	**84.365**	**3.697**	**3.363**	**62.548**	**3.697**	**3.363**	**62.548**	**2.875**	**2.722**	**37.162**	**2.606**
143	**5.888**	**85.245**	**3.754**	**3.383**	**62.729**	**3.754**	**3.383**	**62.729**	**2.900**	**2.742**	**37.444**	**2.638**
144	**5.920**	**86.124**	**3.811**	**3.404**	**62.910**	**3.811**	**3.404**	**62.910**	**2.925**	**2.762**	**37.727**	**2.671**
145	**5.951**	**87.003**	**3.869**	**3.425**	**63.091**	**3.869**	**3.425**	**63.091**	**2.949**	**2.782**	**38.009**	**2.703**
146	**5.975**	**87.915**	**3.892**	**3.453**	**63.539**	**3.892**	**3.453**	**63.539**	**2.959**	**2.797**	**38.632**	**2.715**
147	**5.998**	**88.827**	**3.916**	**3.482**	**63.987**	**3.916**	**3.482**	**63.987**	**2.968**	**2.811**	**39.255**	**2.726**
148	**6.022**	**89.739**	**3.939**	**3.510**	**64.435**	**3.939**	**3.510**	**64.435**	**2.978**	**2.825**	**39.878**	**2.738**
149	**6.046**	**90.652**	**3.963**	**3.539**	**64.883**	**3.963**	**3.539**	**64.883**	**2.987**	**2.839**	**40.501**	**2.750**
150	**6.069**	**91.564**	**3.986**	**3.568**	**65.331**	**3.986**	**3.568**	**65.331**	**2.997**	**2.853**	**41.124**	**2.762**
151	**6.099**	**92.475**	**4.000**	**3.595**	**65.704**	**4.000**	**3.595**	**65.704**	**3.007**	**2.868**	**41.450**	**2.774**
152	**6.129**	**93.387**	**4.014**	**3.623**	**66.077**	**4.014**	**3.623**	**66.077**	**3.017**	**2.883**	**41.776**	**2.786**
153	**6.159**	**94.298**	**4.029**	**3.650**	**66.450**	**4.029**	**3.650**	**66.450**	**3.028**	**2.898**	**42.102**	**2.799**
154	**6.189**	**95.209**	**4.043**	**3.677**	**66.823**	**4.043**	**3.677**	**66.823**	**3.038**	**2.913**	**42.428**	**2.811**
155	**6.219**	**96.121**	**4.057**	**3.705**	**67.197**	**4.057**	**3.705**	**67.197**	**3.049**	**2.927**	**42.754**	**2.823**
156	**6.313**	**97.599**	**4.117**	**3.767**	**69.206**	**4.117**	**3.767**	**69.206**	**3.113**	**2.969**	**44.233**	**2.870**
157	**6.407**	**99.077**	**4.176**	**3.829**	**71.215**	**4.176**	**3.829**	**71.215**	**3.178**	**3.011**	**45.712**	**2.917**
158	**6.501**	**100.555**	**4.236**	**3.891**	**73.225**	**4.236**	**3.891**	**73.225**	**3.242**	**3.053**	**47.191**	**2.964**

159	6.595	102.033	4.295	3.953	75.234	4.295	3.953	75.234	3.307	3.095	48.670	3.011
160	6.689	103.511	4.355	4.015	77.243	4.355	4.015	77.243	3.371	3.136	50.149	3.057
161	7.010	107.552	4.551	4.078	79.985	4.551	4.078	79.985	3.503	3.182	51.569	3.181
162	7.331	111.593	4.747	4.142	82.727	4.747	4.142	82.727	3.635	3.227	52.988	3.306
163	7.652	115.634	4.943	4.205	85.469	4.943	4.205	85.469	3.767	3.272	54.408	3.430
164	7.972	119.676	5.139	4.268	88.211	5.139	4.268	88.211	3.899	3.318	55.828	3.554
165	8.293	123.717	5.335	4.332	90.953	5.335	4.332	90.953	4.030	3.363	57.247	3.678
166	8.671	125.252	5.516	4.380	93.266	5.516	4.380	93.266	4.145	3.410	58.958	3.796
167	9.050	126.786	5.696	4.428	95.579	5.696	4.428	95.579	4.260	3.458	60.670	3.914
168	9.428	128.321	5.876	4.477	97.892	5.876	4.477	97.892	4.375	3.505	62.381	4.033
169	9.806	129.855	6.056	4.525	100.205	6.056	4.525	100.205	4.490	3.552	64.092	4.151
170	10.184	131.390	6.237	4.573	102.517	6.237	4.573	102.517	4.605	3.600	65.804	4.269
171	10.426	132.095	6.345	4.618	103.813	6.345	4.618	103.813	4.673	3.644	66.939	4.322
172	10.667	132.801	6.452	4.664	105.109	6.452	4.664	105.109	4.741	3.688	68.075	4.374
173	10.909	133.506	6.560	4.709	106.404	6.560	4.709	106.404	4.808	3.732	69.210	4.426
174	11.150	134.211	6.668	4.754	107.700	6.668	4.754	107.700	4.876	3.776	70.345	4.479
175	11.392	134.917	6.776	4.799	108.995	6.776	4.799	108.995	4.944	3.821	71.481	4.531
176	11.439	137.703	6.910	4.858	110.733	6.910	4.858	110.733	5.057	3.856	73.077	4.626
177	11.486	140.490	7.045	4.917	112.471	7.045	4.917	112.471	5.171	3.891	74.674	4.722
178	11.533	143.276	7.179	4.977	114.209	7.179	4.977	114.209	5.284	3.927	76.271	4.817
179	11.581	146.063	7.313	5.036	115.946	7.313	5.036	115.946	5.398	3.962	77.867	4.912
180	11.628	148.849	7.447	5.095	117.684	7.447	5.095	117.684	5.511	3.997	79.464	5.008
181	11.671	154.282	7.621	5.158	119.775	7.621	5.158	119.775	5.641	4.024	81.282	5.111
182	11.715	159.715	7.795	5.221	121.866	7.795	5.221	121.866	5.770	4.050	83.100	5.214
183	11.759	165.147	7.969	5.284	123.956	7.969	5.284	123.956	5.900	4.077	84.919	5.318
184	11.803	170.580	8.143	5.347	126.047	8.143	5.347	126.047	6.029	4.104	86.737	5.421
185	11.846	176.013	8.318	5.411	128.138	8.318	5.411	128.138	6.159	4.131	88.555	5.524
186	11.887	179.970	8.499	5.428	129.673	8.499	5.428	129.673	6.285	4.154	90.333	5.656
187	11.928	183.927	8.681	5.446	131.209	8.681	5.446	131.209	6.411	4.178	92.110	5.787
188	11.969	187.884	8.862	5.463	132.745	8.862	5.463	132.745	6.537	4.202	93.888	5.919
189	12.010	191.841	9.043	5.481	134.281	9.043	5.481	134.281	6.663	4.225	95.665	6.050
190	12.051	195.798	9.225	5.499	135.816	9.225	5.499	135.816	6.789	4.249	97.442	6.182
191	12.090	197.691	9.386	5.561	137.198	9.386	5.561	137.198	6.875	4.285	98.856	6.266
192	12.128	199.584	9.547	5.623	138.580	9.547	5.623	138.580	6.961	4.321	100.271	6.350
193	12.166	201.476	9.708	5.686	139.961	9.708	5.686	139.961	7.047	4.357	101.685	6.435
194	12.205	203.369	9.869	5.748	141.343	9.869	5.748	141.343	7.133	4.393	103.099	6.519
195	12.243	205.262	10.030	5.810	142.724	10.030	5.810	142.724	7.219	4.430	104.513	6.603
196	12.281	208.341	10.188	5.828	144.052	10.188	5.828	144.052	7.346	4.460	106.134	6.706
197	12.319	211.419	10.346	5.845	145.381	10.346	5.845	145.381	7.473	4.490	107.755	6.810
198	12.357	214.498	10.504	5.863	146.709	10.504	5.863	146.709	7.600	4.520	109.376	6.913
199	12.395	217.577	10.662	5.880	148.037	10.662	5.880	148.037	7.727	4.550	110.997	7.017
200	12.433	220.656	10.820	5.898	149.365	10.820	5.898	149.365	7.853	4.580	112.617	7.120
201	12.509	221.810	10.948	5.942	150.214	10.948	5.942	150.214	7.929	4.623	113.207	7.195
202	12.585	222.965	11.075	5.986	151.063	11.075	5.986	151.063	8.005	4.666	113.796	7.270
203	12.661	224.119	11.203	6.029	151.912	11.203	6.029	151.912	8.080	4.709	114.385	7.345

204	**12.738**	**225.274**	**11.330**	**6.073**	**152.760**	**11.330**	**6.073**	**152.760**	**8.156**	**4.752**	**114.974**	**7.419**
205	**12.814**	**226.429**	**11.458**	**6.117**	**153.609**	**11.458**	**6.117**	**153.609**	**8.232**	**4.795**	**115.563**	**7.494**
206	**12.891**	**228.364**	**11.530**	**6.174**	**154.888**	**11.530**	**6.174**	**154.888**	**8.295**	**4.848**	**116.847**	**7.544**
207	**12.969**	**230.299**	**11.601**	**6.231**	**156.166**	**11.601**	**6.231**	**156.166**	**8.357**	**4.901**	**118.131**	**7.594**
208	**13.046**	**232.235**	**11.673**	**6.288**	**157.445**	**11.673**	**6.288**	**157.445**	**8.420**	**4.955**	**119.415**	**7.644**
209	**13.124**	**234.170**	**11.745**	**6.345**	**158.724**	**11.745**	**6.345**	**158.724**	**8.483**	**5.008**	**120.699**	**7.694**
210	**13.201**	**236.105**	**11.817**	**6.401**	**160.002**	**11.817**	**6.401**	**160.002**	**8.545**	**5.061**	**121.983**	**7.744**
211	**13.233**	**239.385**	**11.984**	**6.451**	**161.606**	**11.984**	**6.451**	**161.606**	**8.670**	**5.090**	**123.498**	**7.846**
212	**13.264**	**242.664**	**12.152**	**6.500**	**163.210**	**12.152**	**6.500**	**163.210**	**8.794**	**5.119**	**125.012**	**7.948**
213	**13.296**	**245.943**	**12.319**	**6.550**	**164.814**	**12.319**	**6.550**	**164.814**	**8.919**	**5.147**	**126.526**	**8.051**
214	**13.328**	**249.223**	**12.486**	**6.599**	**166.418**	**12.486**	**6.599**	**166.418**	**9.043**	**5.176**	**128.040**	**8.153**
215	**13.359**	**252.502**	**12.653**	**6.649**	**168.022**	**12.653**	**6.649**	**168.022**	**9.168**	**5.204**	**129.554**	**8.255**
216	**13.423**	**253.243**	**12.780**	**6.693**	**168.948**	**12.780**	**6.693**	**168.948**	**9.251**	**5.240**	**130.345**	**8.328**
217	**13.487**	**253.983**	**12.906**	**6.737**	**169.874**	**12.906**	**6.737**	**169.874**	**9.334**	**5.275**	**131.136**	**8.400**
218	**13.551**	**254.724**	**13.032**	**6.782**	**170.800**	**13.032**	**6.782**	**170.800**	**9.417**	**5.310**	**131.928**	**8.472**
219	**13.615**	**255.464**	**13.159**	**6.826**	**171.726**	**13.159**	**6.826**	**171.726**	**9.500**	**5.345**	**132.719**	**8.545**
220	**13.679**	**256.204**	**13.285**	**6.870**	**172.653**	**13.285**	**6.870**	**172.653**	**9.584**	**5.380**	**133.510**	**8.617**
221	**13.852**	**256.417**	**13.314**	**6.946**	**173.200**	**13.314**	**6.946**	**173.200**	**9.598**	**5.436**	**133.899**	**8.630**
222	**14.025**	**256.629**	**13.343**	**7.022**	**173.748**	**13.343**	**7.022**	**173.748**	**9.612**	**5.492**	**134.287**	**8.642**
223	**14.198**	**256.841**	**13.371**	**7.098**	**174.295**	**13.371**	**7.098**	**174.295**	**9.627**	**5.548**	**134.676**	**8.655**
224	**14.371**	**257.053**	**13.400**	**7.173**	**174.843**	**13.400**	**7.173**	**174.843**	**9.641**	**5.604**	**135.064**	**8.667**
225	**14.544**	**257.265**	**13.429**	**7.249**	**175.391**	**13.429**	**7.249**	**175.391**	**9.655**	**5.660**	**135.453**	**8.680**
226	**14.737**	**257.645**	**13.440**	**7.334**	**175.611**	**13.440**	**7.334**	**175.611**	**9.664**	**5.699**	**135.633**	**8.688**
227	**14.929**	**258.025**	**13.452**	**7.419**	**175.831**	**13.452**	**7.419**	**175.831**	**9.674**	**5.738**	**135.814**	**8.696**
228	**15.122**	**258.405**	**13.464**	**7.504**	**176.051**	**13.464**	**7.504**	**176.051**	**9.683**	**5.776**	**135.995**	**8.704**
229	**15.315**	**258.785**	**13.475**	**7.589**	**176.271**	**13.475**	**7.589**	**176.271**	**9.692**	**5.815**	**136.176**	**8.712**
230	**15.507**	**259.165**	**13.487**	**7.674**	**176.491**	**13.487**	**7.674**	**176.491**	**9.701**	**5.854**	**136.356**	**8.720**
231	**15.616**	**259.629**	**13.498**	**7.710**	**176.612**	**13.498**	**7.710**	**176.612**	**9.710**	**5.875**	**136.581**	**8.727**
232	**15.725**	**260.092**	**13.508**	**7.746**	**176.732**	**13.508**	**7.746**	**176.732**	**9.719**	**5.897**	**136.806**	**8.733**
233	**15.834**	**260.556**	**13.519**	**7.782**	**176.853**	**13.519**	**7.782**	**176.853**	**9.728**	**5.918**	**137.031**	**8.740**
234	**15.944**	**261.020**	**13.530**	**7.818**	**176.974**	**13.530**	**7.818**	**176.974**	**9.737**	**5.940**	**137.256**	**8.746**
235	**16.053**	**261.484**	**13.540**	**7.853**	**177.095**	**13.540**	**7.853**	**177.095**	**9.746**	**5.961**	**137.482**	**8.753**
236	**16.085**	**261.890**	**13.551**	**7.867**	**177.463**	**13.551**	**7.867**	**177.463**	**9.754**	**5.977**	**137.680**	**8.760**
237	**16.117**	**262.296**	**13.561**	**7.881**	**177.830**	**13.561**	**7.881**	**177.830**	**9.761**	**5.994**	**137.879**	**8.767**
238	**16.149**	**262.701**	**13.572**	**7.894**	**178.198**	**13.572**	**7.894**	**178.198**	**9.769**	**6.010**	**138.078**	**8.774**
239	**16.181**	**263.107**	**13.582**	**7.908**	**178.566**	**13.582**	**7.908**	**178.566**	**9.777**	**6.026**	**138.277**	**8.781**
240	**16.214**	**263.513**	**13.592**	**7.922**	**178.933**	**13.592**	**7.922**	**178.933**	**9.785**	**6.042**	**138.476**	**8.788**

Appendix C

Fast Pass IM240 Standards Developed for Wisconsin

Fast Pass IM240 Standards Developed for Wisconsin

Wisconsin requested EPA provide fast-pass cutpoints for final and intermediate standards. A method is outlined below. This was applied only to the Appendix. A fast-pass cutpoints but could be used on others also.

1) A scale factor for each pollutant at each second is defined. This was done to calculate the cutpoint at second i for each pollutant at each standard.

For example: HC Scale Factor for the 0.8 cutpoint

FPHC Scale Factor = [HC(0.8)Fast Pass Cutpoint at t= i] / [HC(0.8) Fast Pass Cutpoint at t=239]

2) The ratio of the Fast Pass cutpoint at t=239 to the distance traveled (1.973 mi) was found. This was done so the new fast-pass cut points could be scaled to the new full 240 second standard

For HC (0.8g/mi):

FPHC 239 =	1.615	g
Distance =	1.973	mi
FPHC 239 g/mi =	0.81855	

% above 0.8 g/mi standard = (0.818-0.8)/0.8*100 = 2.2%

For new HC standard (0.6 g/mi):

(FPHC 239 g/mi - 0.6)/0.6 * 100 = 2.2%

(This provides the same 2.2% overshoot as the phase-in fast-pass standards.)

FPHC 239 g/mi = 0.6132g/mi
FPHC 239 g = 1.2098

3) The new fast pass standards will then be calculated as:

HC(0.6)FP = FP(0.6)239 * HCSF(0.8)i

t	HC(0.8) g	FPHC SF	HC(0.6) g
30	0.124	0.0768	0.0929

31	0.126	0.0780	0.0944
.....			
238	1.614	0.9994	1.2091
239	1.615	1.0000	1.2098

4) For Phase 2 cut points, where needed:

Take the old standard, for example, FPHC Phase 2 = 0.5 g/mi

The distance traveled from second 108 to second 239 is 1.359 mi

The old FPHC 239 cutpoint is 0.716 g

In terms of g/mi this is 0.716/1.359 = 0.527 g/mi

The delta between this value and the actual standard is: (0.527-0.5) = 0.027 g/mi

The new FPHC 239 g/mi cutpoint is: 0.4 + 0.027 = 0.427 g/mi . In terms of g, this is FPHC 239 g/mi * 1.359 mi = 0.580 g

The Scale Factor is calculated as before for each second of the test, and the Phase 2 cutpoint at each second is calculated by multiplying this Scale Factor times the new FP cutpoint in g at 239. In this case, that new FP cutpoint would be 0.580 * Scale Factor for each second.

	Hydrocarbon(g)						Carbon Monoxide (g)						Oxides of Nitrogen (g)		
	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2	Composite	Phase 2	Composite	Composite	Composite
Sec	(0.6)	(0.4)	(0.8)	(0.5)	(1.1)	(0.7)	(10.0)	(0.8)	(15.0)	(12.0)	(20.0)	(16.0)	(1.5)	(2.0)	(2.5)
30	0.093	n/a	0.124	n/a	0.226	n/a	0.462	n/a	0.693	n/a	1.502	n/a	0.125	0.167	0.262
31	0.095	n/a	0.126	n/a	0.232	n/a	0.515	n/a	0.773	n/a	1.546	n/a	0.133	0.177	0.275
32	0.097	n/a	0.129	n/a	0.237	n/a	0.558	n/a	0.837	n/a	1.568	n/a	0.141	0.188	0.301
33	0.101	n/a	0.135	n/a	0.241	n/a	0.567	n/a	0.851	n/a	1.582	n/a	0.161	0.214	0.317
34	0.105	n/a	0.140	n/a	0.246	n/a	0.569	n/a	0.853	n/a	1.593	n/a	0.174	0.232	0.327
35	0.110	n/a	0.146	n/a	0.254	n/a	0.571	n/a	0.857	n/a	1.602	n/a	0.180	0.240	0.330
36	0.113	n/a	0.150	n/a	0.259	n/a	0.600	n/a	0.900	n/a	1.621	n/a	0.182	0.243	0.332
37	0.115	n/a	0.153	n/a	0.269	n/a	0.640	n/a	0.960	n/a	1.631	n/a	0.184	0.245	0.334
38	0.117	n/a	0.156	n/a	0.272	n/a	0.689	n/a	1.034	n/a	1.702	n/a	0.185	0.246	0.336
39	0.120	n/a	0.160	n/a	0.273	n/a	0.713	n/a	1.070	n/a	1.784	n/a	0.185	0.246	0.337
40	0.124	n/a	0.165	n/a	0.287	n/a	0.717	n/a	1.076	n/a	1.879	n/a	0.188	0.250	0.354
41	0.127	n/a	0.169	n/a	0.293	n/a	0.722	n/a	1.083	n/a	2.162	n/a	0.195	0.260	0.366
42	0.129	n/a	0.172	n/a	0.300	n/a	0.735	n/a	1.102	n/a	2.307	n/a	0.208	0.277	0.410
43	0.130	n/a	0.173	n/a	0.314	n/a	0.741	n/a	1.111	n/a	2.343	n/a	0.233	0.311	0.414
44	0.133	n/a	0.177	n/a	0.330	n/a	0.743	n/a	1.114	n/a	2.376	n/a	0.246	0.328	0.438
45	0.148	n/a	0.197	n/a	0.345	n/a	0.771	n/a	1.157	n/a	2.406	n/a	0.257	0.343	0.477
46	0.150	n/a	0.200	n/a	0.357	n/a	0.896	n/a	1.344	n/a	2.433	n/a	0.269	0.359	0.506
47	0.156	n/a	0.208	n/a	0.374	n/a	0.988	n/a	1.482	n/a	2.458	n/a	0.280	0.373	0.518
48	0.166	n/a	0.221	n/a	0.388	n/a	1.020	n/a	1.530	n/a	2.483	n/a	0.287	0.383	0.522
49	0.174	n/a	0.232	n/a	0.398	n/a	1.028	n/a	1.542	n/a	2.774	n/a	0.289	0.385	0.526
50	0.176	n/a	0.235	n/a	0.407	n/a	1.035	n/a	1.553	n/a	2.844	n/a	0.300	0.400	0.554
51	0.179	n/a	0.238	n/a	0.416	n/a	1.047	n/a	1.571	n/a	2.900	n/a	0.308	0.410	0.574
52	0.180	n/a	0.240	n/a	0.426	n/a	1.063	n/a	1.595	n/a	2.936	n/a	0.326	0.434	0.587
53	0.182	n/a	0.242	n/a	0.433	n/a	1.089	n/a	1.633	n/a	3.133	n/a	0.348	0.464	0.601
54	0.185	n/a	0.246	n/a	0.438	n/a	1.123	n/a	1.685	n/a	3.304	n/a	0.354	0.472	0.615
55	0.187	n/a	0.249	n/a	0.445	n/a	1.126	n/a	1.689	n/a	3.407	n/a	0.360	0.480	0.629
56	0.189	n/a	0.252	n/a	0.452	n/a	1.129	n/a	1.693	n/a	3.456	n/a	0.368	0.491	0.643
57	0.196	n/a	0.261	n/a	0.458	n/a	1.133	n/a	1.700	n/a	3.480	n/a	0.375	0.500	0.667
58	0.203	n/a	0.271	n/a	0.463	n/a	1.149	n/a	1.723	n/a	3.518	n/a	0.380	0.506	0.678
59	0.207	n/a	0.276	n/a	0.471	n/a	1.235	n/a	1.852	n/a	3.560	n/a	0.382	0.509	0.683
60	0.209	n/a	0.278	n/a	0.492	n/a	1.248	n/a	1.872	n/a	3.593	n/a	0.384	0.512	0.686
61	0.210	n/a	0.280	n/a	0.495	n/a	1.248	n/a	1.872	n/a	3.628	n/a	0.387	0.516	0.693
62	0.212	n/a	0.282	n/a	0.498	n/a	1.248	n/a	1.872	n/a	3.641	n/a	0.389	0.519	0.699
63	0.212	n/a	0.283	n/a	0.501	n/a	1.267	n/a	1.900	n/a	3.655	n/a	0.392	0.523	0.703
64	0.213	n/a	0.284	n/a	0.505	n/a	1.278	n/a	1.917	n/a	3.680	n/a	0.397	0.529	0.707
65	0.214	n/a	0.285	n/a	0.512	n/a	1.296	n/a	1.944	n/a	3.700	n/a	0.400	0.533	0.711
66	0.215	n/a	0.286	n/a	0.520	n/a	1.333	n/a	2.000	n/a	3.728	n/a	0.401	0.535	0.716
67	0.216	n/a	0.288	n/a	0.527	n/a	1.373	n/a	2.060	n/a	3.857	n/a	0.405	0.540	0.721
68	0.218	n/a	0.291	n/a	0.539	n/a	1.376	n/a	2.064	n/a	3.894	n/a	0.413	0.551	0.726
69	0.221	n/a	0.294	n/a	0.545	n/a	1.384	n/a	2.076	n/a	3.943	n/a	0.422	0.563	0.742
70	0.222	n/a	0.296	n/a	0.551	n/a	1.403	n/a	2.104	n/a	3.983	n/a	0.431	0.575	0.759
71	0.224	n/a	0.298	n/a	0.556	n/a	1.411	n/a	2.117	n/a	4.009	n/a	0.441	0.588	0.773
72	0.225	n/a	0.300	n/a	0.559	n/a	1.417	n/a	2.125	n/a	4.023	n/a	0.450	0.600	0.784
73	0.227	n/a	0.302	n/a	0.566	n/a	1.420	n/a	2.130	n/a	4.023	n/a	0.452	0.603	0.790
74	0.228	n/a	0.304	n/a	0.578	n/a	1.425	n/a	2.138	n/a	4.053	n/a	0.453	0.604	0.794
75	0.230	n/a	0.307	n/a	0.589	n/a	1.435	n/a	2.152	n/a	4.063	n/a	0.460	0.613	0.799
76	0.231	n/a	0.308	n/a	0.597	n/a	1.447	n/a	2.170	n/a	4.077	n/a	0.468	0.624	0.809
77	0.231	n/a	0.308	n/a	0.604	n/a	1.459	n/a	2.188	n/a	4.225	n/a	0.485	0.646	0.821

78	0.231	n/a	0.308	n/a	0.611	n/a	1.467	n/a	2.200	n/a	4.243	n/a	0.488	0.651	0.833
79	0.236	n/a	0.314	n/a	0.620	n/a	1.475	n/a	2.212	n/a	4.260	n/a	0.494	0.659	0.839
80	0.240	n/a	0.320	n/a	0.624	n/a	1.475	n/a	2.212	n/a	4.282	n/a	0.505	0.673	0.844
81	0.243	n/a	0.324	n/a	0.628	n/a	1.481	n/a	2.221	n/a	4.322	n/a	0.522	0.696	0.857
82	0.245	n/a	0.327	n/a	0.632	n/a	1.481	n/a	2.222	n/a	4.398	n/a	0.530	0.706	0.870
83	0.247	n/a	0.329	n/a	0.636	n/a	1.485	n/a	2.227	n/a	4.482	n/a	0.536	0.715	0.883
84	0.250	n/a	0.333	n/a	0.642	n/a	1.491	n/a	2.236	n/a	4.515	n/a	0.543	0.724	0.894
85	0.252	n/a	0.336	n/a	0.646	n/a	1.495	n/a	2.243	n/a	4.518	n/a	0.553	0.737	0.902
86	0.254	n/a	0.339	n/a	0.650	n/a	1.508	n/a	2.262	n/a	4.520	n/a	0.560	0.747	0.907
87	0.257	n/a	0.343	n/a	0.654	n/a	1.514	n/a	2.271	n/a	4.522	n/a	0.561	0.748	0.910
88	0.260	n/a	0.347	n/a	0.657	n/a	1.523	n/a	2.284	n/a	4.522	n/a	0.561	0.748	0.912
89	0.263	n/a	0.350	n/a	0.661	n/a	1.533	n/a	2.299	n/a	4.523	n/a	0.561	0.748	0.913
90	0.267	n/a	0.356	n/a	0.664	n/a	1.539	n/a	2.308	n/a	4.526	n/a	0.561	0.748	0.914
91	0.269	n/a	0.358	n/a	0.666	n/a	1.551	n/a	2.326	n/a	4.527	n/a	0.561	0.748	0.915
92	0.270	n/a	0.360	n/a	0.668	n/a	1.553	n/a	2.330	n/a	4.527	n/a	0.561	0.748	0.916
93	0.272	n/a	0.363	n/a	0.670	n/a	1.554	n/a	2.331	n/a	4.528	n/a	0.561	0.748	0.917
94	0.275	n/a	0.367	n/a	0.673	n/a	1.563	n/a	2.344	n/a	4.528	n/a	0.561	0.748	0.918
95	0.278	n/a	0.370	n/a	0.678	n/a	1.565	n/a	2.347	n/a	4.528	n/a	0.561	0.748	0.919
96	0.279	n/a	0.372	n/a	0.686	n/a	1.570	n/a	2.355	n/a	4.529	n/a	0.561	0.748	0.920
97	0.282	n/a	0.376	n/a	0.696	n/a	1.597	n/a	2.395	n/a	4.575	n/a	0.561	0.748	0.921
98	0.291	n/a	0.388	n/a	0.707	n/a	1.634	n/a	2.451	n/a	4.703	n/a	0.561	0.748	0.922
99	0.297	n/a	0.396	n/a	0.718	n/a	1.672	n/a	2.508	n/a	4.805	n/a	0.563	0.751	0.924
100	0.304	n/a	0.405	n/a	0.727	n/a	1.727	n/a	2.590	n/a	4.886	n/a	0.573	0.764	0.929
101	0.308	n/a	0.410	n/a	0.743	n/a	1.773	n/a	2.660	n/a	4.957	n/a	0.592	0.789	0.941
102	0.308	n/a	0.411	n/a	0.754	n/a	1.833	n/a	2.749	n/a	5.104	n/a	0.617	0.822	0.970
103	0.309	n/a	0.412	n/a	0.766	n/a	1.942	n/a	2.913	n/a	5.340	n/a	0.650	0.867	1.027
104	0.310	n/a	0.413	n/a	0.782	n/a	2.108	n/a	3.162	n/a	5.496	n/a	0.679	0.905	1.093
105	0.316	n/a	0.421	n/a	0.798	n/a	2.113	n/a	3.170	n/a	5.625	n/a	0.694	0.925	1.155
106	0.321	n/a	0.428	n/a	0.813	n/a	2.131	n/a	3.197	n/a	5.815	n/a	0.716	0.955	1.234
107	0.323	n/a	0.430	n/a	0.824	n/a	2.192	n/a	3.288	n/a	6.473	n/a	0.739	0.985	1.275
108	0.341	n/a	0.455	n/a	0.853	n/a	2.279	n/a	3.419	n/a	7.037	n/a	0.745	0.993	1.305
109	0.344	0.012	0.459	0.015	0.868	0.037	2.391	0.115	3.587	0.168	7.419	0.246	0.746	0.995	1.320
110	0.347	0.014	0.462	0.017	0.877	0.044	2.397	0.119	3.595	0.173	7.643	0.257	0.747	0.996	1.332
111	0.348	0.017	0.464	0.021	0.885	0.049	2.427	0.163	3.640	0.237	7.759	0.286	0.758	1.010	1.346
112	0.350	0.019	0.466	0.024	0.890	0.052	2.493	0.183	3.740	0.266	7.824	0.379	0.771	1.028	1.358
113	0.351	0.019	0.468	0.024	0.896	0.057	2.579	0.192	3.868	0.280	7.889	0.425	0.776	1.034	1.378
114	0.353	0.020	0.471	0.025	0.901	0.060	2.585	0.200	3.877	0.291	7.960	0.457	0.783	1.044	1.406
115	0.366	0.021	0.488	0.026	0.919	0.067	2.623	0.216	3.934	0.314	8.024	0.477	0.794	1.059	1.426
116	0.385	0.023	0.513	0.029	0.944	0.076	2.677	0.227	4.015	0.331	8.076	0.494	0.806	1.075	1.438
117	0.404	0.026	0.538	0.032	0.954	0.077	2.707	0.237	4.061	0.345	8.111	0.504	0.810	1.080	1.448
118	0.421	0.028	0.561	0.035	0.963	0.078	2.709	0.240	4.063	0.350	8.130	0.512	0.810	1.080	1.460
119	0.433	0.028	0.577	0.035	0.964	0.086	2.719	0.245	4.079	0.356	8.148	0.519	0.811	1.081	1.462
120	0.435	0.029	0.580	0.036	0.967	0.088	2.760	0.252	4.140	0.367	8.211	0.529	0.818	1.091	1.467
121	0.440	0.031	0.586	0.038	0.973	0.091	2.790	0.267	4.185	0.388	8.478	0.529	0.822	1.096	1.476
122	0.446	0.032	0.594	0.040	0.982	0.094	2.799	0.280	4.199	0.407	8.548	0.530	0.833	1.111	1.494
123	0.452	0.033	0.603	0.041	0.991	0.096	2.803	0.318	4.205	0.463	8.561	0.531	0.842	1.122	1.505
124	0.458	0.034	0.610	0.042	1.000	0.099	2.808	0.330	4.212	0.480	8.568	0.532	0.851	1.135	1.517
125	0.461	0.034	0.615	0.042	1.010	0.101	2.821	0.348	4.232	0.506	8.572	0.533	0.854	1.138	1.546
126	0.468	0.034	0.624	0.042	1.018	0.103	2.865	0.356	4.298	0.518	8.584	0.548	0.854	1.139	1.569
127	0.471	0.036	0.628	0.045	1.023	0.105	2.896	0.359	4.344	0.522	8.592	0.610	0.854	1.139	1.586
128	0.474	0.037	0.632	0.046	1.028	0.107	2.907	0.361	4.361	0.525	8.596	0.614	0.854	1.139	1.596
129	0.478	0.037	0.637	0.046	1.031	0.109	2.911	0.363	4.366	0.528	8.597	0.622	0.854	1.139	1.603
130	0.481	0.040	0.641	0.049	1.034	0.111	2.913	0.364	4.369	0.530	8.601	0.631	0.854	1.139	1.605

131	0.482	0.041	0.643	0.050	1.036	0.112	2.915	0.364	4.372	0.530	8.605	0.640	0.854	1.139	1.606
132	0.483	0.042	0.644	0.052	1.038	0.114	2.957	0.367	4.435	0.534	8.608	0.646	0.854	1.139	1.607
133	0.484	0.044	0.645	0.054	1.040	0.115	3.015	0.378	4.523	0.550	8.626	0.650	0.854	1.139	1.607
134	0.485	0.044	0.647	0.054	1.040	0.116	3.016	0.381	4.524	0.554	8.650	0.652	0.854	1.139	1.608
135	0.488	0.044	0.651	0.054	1.048	0.119	3.017	0.405	4.525	0.590	8.660	0.738	0.854	1.139	1.614
136	0.494	0.045	0.658	0.055	1.051	0.122	3.021	0.423	4.531	0.616	8.767	0.754	0.870	1.160	1.616
137	0.497	0.045	0.663	0.055	1.060	0.126	3.023	0.439	4.534	0.639	9.029	0.780	0.881	1.174	1.631
138	0.500	0.045	0.666	0.056	1.066	0.130	3.028	0.449	4.542	0.653	9.238	0.795	0.887	1.183	1.643
139	0.501	0.048	0.668	0.059	1.087	0.137	3.035	0.455	4.553	0.662	9.389	0.804	0.898	1.197	1.656
140	0.503	0.049	0.670	0.061	1.149	0.140	3.036	0.469	4.554	0.683	9.493	0.810	0.917	1.223	1.673
141	0.504	0.049	0.672	0.061	1.157	0.141	3.036	0.478	4.554	0.696	9.583	0.815	0.941	1.255	1.703
142	0.506	0.049	0.675	0.061	1.165	0.143	3.036	0.486	4.554	0.708	9.626	0.818	0.954	1.272	1.739
143	0.509	0.051	0.678	0.063	1.171	0.145	3.036	0.495	4.554	0.721	9.669	0.821	0.965	1.286	1.767
144	0.511	0.052	0.681	0.064	1.176	0.147	3.036	0.508	4.554	0.739	9.716	0.825	0.978	1.304	1.774
145	0.513	0.053	0.684	0.065	1.183	0.152	3.036	0.510	4.554	0.742	9.763	0.840	0.980	1.307	1.785
146	0.515	0.053	0.686	0.066	1.186	0.154	3.036	0.510	4.554	0.743	9.809	0.847	0.984	1.312	1.806
147	0.516	0.054	0.688	0.067	1.188	0.156	3.036	0.512	4.554	0.745	9.852	0.855	0.988	1.317	1.830
148	0.518	0.055	0.690	0.068	1.190	0.157	3.036	0.514	4.554	0.748	9.885	0.865	0.991	1.321	1.844
149	0.519	0.056	0.692	0.069	1.194	0.158	3.036	0.516	4.554	0.751	9.932	0.874	0.994	1.325	1.845
150	0.521	0.057	0.694	0.070	1.206	0.159	3.036	0.524	4.554	0.762	9.986	0.891	0.996	1.328	1.846
151	0.522	0.058	0.696	0.071	1.219	0.160	3.037	0.542	4.556	0.789	10.039	0.914	0.999	1.332	1.852
152	0.524	0.058	0.698	0.072	1.230	0.161	3.037	0.543	4.556	0.790	10.072	0.929	1.004	1.338	1.868
153	0.525	0.059	0.700	0.073	1.236	0.162	3.043	0.546	4.565	0.794	10.090	0.937	1.008	1.344	1.877
154	0.527	0.059	0.702	0.073	1.240	0.164	3.075	0.549	4.612	0.799	10.105	0.942	1.013	1.350	1.879
155	0.528	0.060	0.704	0.074	1.249	0.167	3.223	0.553	4.834	0.805	10.146	0.949	1.018	1.357	1.886
156	0.530	0.062	0.706	0.077	1.251	0.169	3.801	0.578	5.702	0.842	10.245	1.375	1.024	1.365	1.900
157	0.531	0.064	0.708	0.079	1.252	0.177	3.894	0.680	5.841	0.990	10.397	1.576	1.034	1.379	1.910
158	0.533	0.066	0.710	0.082	1.259	0.185	4.113	0.713	6.170	1.038	10.923	1.943	1.061	1.414	1.936
159	0.534	0.066	0.712	0.082	1.281	0.190	4.447	0.932	6.670	1.357	11.970	2.820	1.100	1.466	1.954
160	0.537	0.070	0.716	0.086	1.304	0.194	4.950	1.000	7.425	1.455	13.421	3.281	1.136	1.514	1.986
161	0.563	0.077	0.750	0.095	1.320	0.200	5.586	1.062	8.379	1.546	15.289	3.483	1.169	1.559	2.050
162	0.588	0.087	0.784	0.107	1.331	0.207	6.432	1.253	9.648	1.824	15.912	3.620	1.193	1.591	2.131
163	0.604	0.093	0.805	0.115	1.343	0.215	7.279	1.887	10.918	2.746	16.530	4.168	1.231	1.641	2.235
164	0.630	0.099	0.840	0.122	1.383	0.231	8.105	2.111	12.157	3.073	17.622	4.338	1.289	1.719	2.320
165	0.640	0.103	0.853	0.127	1.405	0.257	8.487	2.496	12.731	3.633	18.366	4.682	1.333	1.777	2.395
166	0.656	0.129	0.874	0.159	1.425	0.289	8.554	3.095	12.831	4.505	19.869	5.633	1.374	1.832	2.488
167	0.677	0.151	0.903	0.186	1.445	0.298	8.595	3.402	12.892	4.952	20.711	6.137	1.439	1.919	2.563
168	0.683	0.153	0.910	0.189	1.465	0.302	8.621	3.610	12.932	5.254	22.319	6.853	1.479	1.972	2.645
169	0.686	0.162	0.914	0.200	1.483	0.312	9.135	3.937	13.702	5.730	23.751	7.136	1.510	2.013	2.746
170	0.687	0.178	0.916	0.220	1.500	0.321	9.426	4.157	14.139	6.051	24.842	7.320	1.575	2.100	2.778
171	0.689	0.191	0.919	0.236	1.527	0.333	9.976	4.351	14.964	6.333	25.410	7.685	1.650	2.200	2.792
172	0.698	0.200	0.931	0.247	1.545	0.361	10.469	4.459	15.704	6.490	25.798	8.052	1.688	2.251	2.810
173	0.711	0.208	0.948	0.257	1.582	0.383	10.835	4.669	16.253	6.796	26.122	8.344	1.703	2.270	2.847
174	0.737	0.216	0.983	0.267	1.597	0.406	11.271	4.950	16.907	7.205	26.353	8.602	1.726	2.301	2.874
175	0.764	0.229	1.018	0.283	1.610	0.424	11.770	5.600	17.655	8.151	26.638	8.898	1.739	2.318	2.905
176	0.770	0.239	1.027	0.295	1.622	0.434	12.013	5.654	18.020	8.230	27.219	9.251	1.751	2.335	2.950
177	0.776	0.253	1.035	0.312	1.635	0.475	12.233	5.898	18.349	8.584	27.279	10.253	1.762	2.349	3.001
178	0.788	0.258	1.051	0.318	1.652	0.490	12.447	6.046	18.671	8.800	27.320	10.828	1.790	2.387	3.047
179	0.806	0.262	1.074	0.323	1.670	0.495	12.648	6.078	18.972	8.847	27.352	10.933	1.817	2.423	3.104
180	0.813	0.273	1.084	0.337	1.689	0.507	12.819	6.124	19.228	8.913	27.822	11.060	1.847	2.462	3.173
181	0.824	0.280	1.099	0.345	1.709	0.514	13.415	6.267	20.123	9.122	28.763	11.188	1.877	2.503	3.238
182	0.841	0.284	1.121	0.350	1.727	0.524	13.603	6.549	20.405	9.532	29.402	11.345	1.909	2.545	3.302
183	0.849	0.291	1.132	0.359	1.738	0.535	13.836	7.046	20.754	10.256	29.971	11.733	1.940	2.586	3.372

184	0.864	0.314	1.152	0.387	1.755	0.547	14.456	7.463	21.684	10.862	30.276	12.598	1.970	2.627	3.452
185	0.871	0.322	1.161	0.398	1.778	0.560	14.637	7.555	21.955	10.996	30.988	12.953	2.005	2.673	3.545
186	0.876	0.324	1.168	0.400	1.795	0.574	15.100	7.699	22.650	11.206	31.095	13.213	2.062	2.749	3.648
187	0.881	0.326	1.175	0.402	1.808	0.585	15.326	7.911	22.989	11.514	31.314	14.131	2.103	2.804	3.701
188	0.886	0.328	1.181	0.405	1.820	0.589	15.690	8.172	23.535	11.894	31.833	14.839	2.138	2.851	3.759
189	0.891	0.339	1.188	0.418	1.825	0.589	15.917	8.258	23.876	12.019	32.239	15.137	2.171	2.894	3.821
190	0.902	0.348	1.203	0.429	1.827	0.598	16.012	8.361	24.018	12.170	32.547	15.138	2.198	2.931	3.870
191	0.914	0.358	1.219	0.442	1.829	0.607	16.309	8.600	24.464	12.517	32.855	15.141	2.228	2.971	3.892
192	0.925	0.370	1.233	0.457	1.834	0.617	16.457	8.655	24.685	12.598	33.153	15.595	2.265	3.020	3.914
193	0.938	0.383	1.251	0.473	1.847	0.621	16.621	8.674	24.931	12.625	33.444	15.658	2.308	3.077	3.955
194	0.941	0.395	1.255	0.487	1.862	0.629	16.792	8.693	25.188	12.653	33.482	15.704	2.349	3.132	3.997
195	0.944	0.406	1.258	0.501	1.876	0.638	16.979	8.778	25.468	12.777	33.516	15.729	2.389	3.185	4.035
196	0.949	0.413	1.265	0.510	1.891	0.649	17.085	8.867	25.627	12.906	33.549	16.058	2.414	3.219	4.089
197	0.960	0.415	1.280	0.512	1.906	0.664	17.164	8.924	25.746	12.989	33.653	16.987	2.451	3.268	4.146
198	0.970	0.416	1.293	0.514	1.920	0.679	17.233	8.973	25.850	13.060	33.973	17.064	2.474	3.299	4.206
199	0.976	0.418	1.301	0.516	1.933	0.693	17.316	9.045	25.974	13.165	34.159	17.073	2.513	3.350	4.243
200	0.985	0.420	1.313	0.518	1.945	0.706	17.427	9.098	26.141	13.242	34.191	17.153	2.555	3.406	4.295
201	0.993	0.427	1.324	0.527	1.953	0.719	17.483	9.215	26.225	13.412	34.250	17.332	2.600	3.466	4.351
202	0.999	0.438	1.332	0.540	1.959	0.726	17.559	9.386	26.338	13.662	34.469	17.406	2.623	3.497	4.398
203	1.006	0.443	1.341	0.547	1.977	0.737	17.698	9.463	26.547	13.773	34.716	17.641	2.636	3.514	4.410
204	1.018	0.448	1.357	0.553	1.991	0.745	17.879	9.579	26.818	13.942	34.969	17.922	2.638	3.517	4.419
205	1.031	0.453	1.375	0.559	2.011	0.752	18.035	9.680	27.052	14.090	35.144	18.484	2.639	3.519	4.426
206	1.044	0.456	1.392	0.563	2.037	0.800	18.262	9.773	27.393	14.224	35.418	18.553	2.642	3.523	4.429
207	1.056	0.459	1.408	0.567	2.058	0.805	18.334	9.911	27.501	14.426	35.766	18.658	2.659	3.545	4.453
208	1.067	0.463	1.422	0.571	2.079	0.817	18.421	9.961	27.632	14.498	35.949	18.953	2.678	3.570	4.486
209	1.075	0.466	1.433	0.575	2.089	0.836	18.535	10.152	27.803	14.776	36.010	19.266	2.700	3.600	4.542
210	1.082	0.469	1.443	0.579	2.097	0.839	18.635	10.242	27.953	14.907	36.548	19.309	2.714	3.619	4.598
211	1.090	0.482	1.453	0.595	2.109	0.846	18.803	10.248	28.205	14.916	37.179	19.731	2.729	3.639	4.638
212	1.097	0.490	1.463	0.605	2.123	0.866	19.029	10.315	28.543	15.014	37.651	19.902	2.765	3.686	4.715
213	1.101	0.497	1.468	0.614	2.138	0.879	19.331	10.458	28.997	15.221	38.041	20.012	2.799	3.732	4.774
214	1.103	0.504	1.470	0.622	2.150	0.882	19.333	10.630	29.000	15.472	38.591	20.260	2.843	3.791	4.829
215	1.106	0.508	1.474	0.627	2.158	0.891	19.337	10.687	29.005	15.555	38.852	20.739	2.875	3.833	4.872
216	1.109	0.517	1.478	0.638	2.165	0.905	19.387	10.754	29.081	15.652	38.861	21.346	2.918	3.890	4.931
217	1.111	0.521	1.481	0.643	2.171	0.917	19.521	10.971	29.281	15.969	38.926	21.810	2.949	3.932	4.960
218	1.113	0.521	1.484	0.643	2.178	0.918	19.655	11.012	29.483	16.028	39.194	22.001	2.970	3.960	4.963
219	1.115	0.523	1.487	0.645	2.185	0.919	19.823	11.250	29.734	16.375	39.474	22.290	2.998	3.997	4.965
220	1.118	0.527	1.490	0.651	2.192	0.941	19.869	11.327	29.803	16.487	39.668	22.324	3.010	4.013	4.968
221	1.120	0.531	1.493	0.655	2.195	0.952	19.881	11.353	29.821	16.524	39.781	22.343	3.026	4.035	4.971
222	1.128	0.537	1.504	0.663	2.200	0.957	19.898	11.390	29.847	16.578	39.890	22.522	3.029	4.038	4.974
223	1.142	0.544	1.522	0.671	2.205	0.963	19.908	11.463	29.862	16.684	39.954	22.661	3.038	4.050	4.977
224	1.160	0.547	1.547	0.675	2.208	0.970	19.915	11.511	29.873	16.755	39.984	22.666	3.050	4.066	4.979
225	1.162	0.554	1.549	0.684	2.212	0.975	20.005	11.522	30.008	16.770	39.989	22.667	3.053	4.070	4.980
226	1.172	0.562	1.562	0.694	2.214	0.979	20.084	11.546	30.126	16.805	39.990	22.668	3.054	4.072	4.981
227	1.181	0.568	1.574	0.701	2.216	0.985	20.085	11.587	30.127	16.865	39.990	22.669	3.054	4.072	4.982
228	1.184	0.569	1.579	0.702	2.217	0.988	20.085	11.652	30.127	16.960	39.990	22.670	3.055	4.073	4.983
229	1.188	0.574	1.584	0.708	2.218	0.992	20.139	11.652	30.208	16.960	39.991	22.671	3.055	4.073	4.984
230	1.192	0.574	1.589	0.708	2.219	0.995	20.209	11.654	30.314	16.962	40.012	22.671	3.055	4.073	4.985
231	1.193	0.574	1.590	0.709	2.221	0.996	20.215	11.672	30.323	16.988	40.061	22.672	3.055	4.073	4.986
232	1.197	0.575	1.596	0.710	2.223	0.996	20.217	11.729	30.325	17.072	40.116	22.673	3.056	4.074	4.987
233	1.199	0.575	1.598	0.710	2.225	0.996	20.245	11.744	30.368	17.094	40.249	22.673	3.056	4.074	4.988
234	1.203	0.576	1.604	0.711	2.227	0.997	20.274	11.806	30.411	17.184	40.253	22.673	3.056	4.075	4.989
235	1.208	0.577	1.610	0.712	2.228	0.997	20.277	11.808	30.416	17.187	40.290	22.674	3.056	4.075	4.990
236	1.209	0.577	1.612	0.712	2.228	0.999	20.285	11.809	30.428	17.188	40.385	22.675	3.057	4.076	4.991

237	**1.210**	**0.577**	**1.613**	**0.712**	**2.229**	**1.001**	**20.287**	**11.810**	**30.430**	**17.189**	**40.488**	**22.675**	**3.057**	**4.076**	**4.992**
238	**1.211**	**0.578**	**1.614**	**0.713**	**2.230**	**1.004**	**20.301**	**11.845**	**30.452**	**17.241**	**40.720**	**22.675**	**3.057**	**4.076**	**4.993**
239	**1.211**	**0.580**	**1.615**	**0.716**	**2.231**	**1.007**	**20.325**	**11.934**	**30.488**	**17.370**	**40.763**	**22.677**	**3.057**	**4.076**	**4.994**

Appendix D

Fast Pass IM240 Standards: Modal Regression Technique

Developed by Sierra Research
Contract 68-C4-0056 Work Assignment 2-04

Fast Pass IM240 Standards: Modal Regression Technique

Sierra Research
Contract 68-C4-0056 Work Assignment 2-04

Development of Fast-Pass Standards

This method differs from those presented in Appendices A, B, and C in that second-by-second standards are not used, rather the second-by-second emissions are used to project a final IM240 score which is then compared to the appropriate IM240 standard as listed on pages 1-4 of this document. A sample of the regression coefficients used to project the full IM240 scores are presented in this appendix. The complete set of coefficients, including an example calculation, can be downloaded from the EPA web site.

Full-duration, second-by-second IM240 data collected in the Arizona I/M program were used for this analysis. Nearly 110,000 individual tests were in the database used in the analysis, which is comprised of all full-duration IM240 tests conducted in Arizona from April 1995 through April 1997. Regression coefficients were generated separately for light-duty gasoline vehicles (i.e., passenger cars) and light-duty trucks for the following model year groups listed below.

- 1981 to 1984,
- 1985 to 1989, and
- 1990 and later.

Regression coefficients were developed for HC, CO, and NOx and for both the composite IM240 and for Phase 2 of the IM240 after dividing the IM240 drive trace into 24 separate modes. The Phase 2 regressions used mode 11 as the first mode and continued through mode 23. The composite IM240 regressions used modes 1 through 23. (Although the trace was divided into 24 modes, if a fast-pass decision is not made by mode 23, then the vehicle would run the full IM240. At that point, a pass/fail decision should be made on the actual IM240 score, not the predicted score.) Finally, it is recommended that the first mode at which a pass/fail decision should be made is mode 4 (which ends at second 32 of the IM240) for a composite IM240 prediction, or mode 13 (which ends at second 113 of the IM240) for a Phase 2 prediction.

The regression coefficients for a 0.8 g/mi HC composite IM240 cutpoint are given in this appendix, along with the coefficients for a 0.5 g/mi HC Phase 2 IM240 cutpoint. The full series of regression coefficients developed in this effort were provided to EPA electronically, and are available on the OMS web page.

Using the 2% Random Sample from the Arizona program (which consists of 26,000 records), pass/fail rates were calculated with the modal regression procedures outlined above as well as the current fast-pass cutpoint tables. This analysis was performed using the final IM240 HC, CO, and NOx standards, and the results are presented in Table D1.

As observed in Table D1, the revised fast-pass methodology results in a lower fraction of false passes than the current method, particularly for older cars. However, this improvement in failing vehicle identification is offset by a longer average test time for passing vehicles in the older model year groups. For newer vehicles (i.e., 1990 and later), the revised methodology results in significant improvements in average test time, without a significant increase in the fraction of false passes.

Table D1 Comparison of Current and Revised Fast-Pass Methodologies Under the Final IM240 Standards (26,000 Vehicle Sample)						
Vehicle Class	Model Year Group	"True" Failure Rate[a]	Current Fast-Pass		Revised Fast-Pass	
			Failure Rate	Pass Time (seconds)	Failure Rate	Pass Time (seconds)
LDV	81 - 84	79%	76%	125	78%	157
	85 - 89	45%	41%	130	43%	121
	1990+	8%	7%	88	7%	57
LDT	81 - 84	62%	51%	71	60%	113
	85 - 89	42%	35%	70	40%	93
	1990+	9%	7%	60	7%	57

[a] The "true" failure rate is based on full-duration IM240 test scores.

Composite IM240 HC Regression Coefficients Developed from Modal IM240 Data Analysis
1981-1984 Model Year Light-Duty Gasoline Vehicles
0.8 g/mi Cutpoint

			Regression Coefficients																						
Mode	RMS Error	Const	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
M1	0.301	0.566	5.043	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M2	0.253	0.378	0.187	2.802	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M3	0.247	0.371	-0.383	2.022	2.586	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M4	0.232	0.337	-0.363	0.828	0.771	3.854	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M5	0.228	0.325	-0.454	1.046	-0.497	2.884	3.156	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M6	0.214	0.286	0.371	0.566	0.327	-0.040	1.592	4.850	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M7	0.202	0.274	0.697	0.468	0.136	-0.077	1.315	2.032	2.632	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M8	0.194	0.260	0.489	0.715	-0.044	-0.411	1.211	2.268	0.853	2.410	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M9	0.189	0.247	0.452	0.747	0.049	-0.370	1.228	2.028	0.757	0.664	2.993	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M10	0.185	0.242	0.163	0.947	-0.410	-0.223	0.801	1.855	0.909	0.463	2.017	2.189	.	.	.	.	.	.	.	.	.	.	.	.	.
M11	0.182	0.236	-0.613	1.036	-0.076	-0.458	0.652	1.882	0.997	0.312	1.900	1.397	4.130	.	.	.	.	.	.	.	.	.	.	.	.
M12	0.160	0.179	0.127	0.496	0.458	-0.049	0.861	0.657	0.532	0.742	0.756	1.363	1.119	2.786	.	.	.	.	.	.	.	.	.	.	.
M13	0.151	0.160	0.257	0.519	0.463	-0.050	0.494	0.783	0.574	0.498	0.793	1.013	1.266	2.081	2.388	.	.	.	.	.	.	.	.	.	.
M14	0.149	0.156	0.285	0.535	0.377	0.080	0.324	0.741	0.578	0.480	0.878	0.729	1.310	2.069	1.748	1.228	.	.	.	.	.	.	.	.	.
M15	0.146	0.152	0.397	0.612	0.326	-0.091	0.754	0.525	0.543	0.420	0.631	0.591	0.768	1.894	1.505	0.562	2.644	.	.	.	.	.	.	.	.
M16	0.144	0.150	0.428	0.652	0.276	-0.140	0.404	0.656	0.668	0.406	0.658	0.454	-0.393	1.833	1.390	0.498	1.810	1.915	.	.	.	.	.	.	.
M17	0.140	0.142	0.463	0.579	0.511	-0.148	0.619	0.189	0.756	0.455	0.462	0.632	-0.086	1.551	1.247	0.516	0.846	1.432	2.815	.	.	.	.	.	.
M18	0.138	0.140	0.505	0.566	0.462	-0.015	0.443	0.386	0.676	0.317	0.386	0.622	-0.033	1.600	1.086	0.435	0.399	1.133	1.908	1.738	.	.	.	.	.
M19	0.134	0.128	0.506	0.528	0.820	-0.205	0.294	0.539	0.735	0.259	0.147	1.098	-0.693	1.478	0.929	0.550	0.693	0.252	1.463	1.566	1.476	.	.	.	.
M20	0.102	0.058	0.441	0.520	0.567	0.283	0.334	0.275	0.678	0.396	0.600	1.082	0.232	0.525	0.815	0.244	0.831	1.083	0.721	1.244	0.809	0.931	.	.	.
M21	0.068	0.032	0.507	0.551	0.501	0.508	0.307	0.466	0.393	0.487	0.542	1.195	0.446	0.329	0.563	0.546	0.500	0.690	0.700	0.763	0.805	0.426	1.089	.	.
M22	0.041	0.013	0.518	0.516	0.564	0.503	0.329	0.622	0.398	0.508	0.395	1.055	0.557	0.394	0.483	0.526	0.715	0.469	0.615	0.618	0.444	0.540	0.430	1.148	.
M23	0.030	0.007	0.517	0.526	0.512	0.515	0.448	0.487	0.455	0.519	0.429	0.938	0.682	0.389	0.577	0.509	0.500	0.654	0.403	0.575	0.458	0.517	0.386	0.681	0.819

NOTE: Results for only 23 modes are shown here because if the 24^{th} mode is completed the actual IM240 score would then be used rather than the predicted score.

Phase 2 IM240 HC Regression Coefficients Developed from Modal IM240 Data Analysis
1981-1984 Model Year Light-Duty Gasoline Vehicles
0.5 g/mi Cutpoint

			Regression Coefficients												
Mode Number	RMS Error	Reg. Const.	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
P11	0.179	0.346	8.141	.	.	.	.	.	.	.	.	.	.	.	.
P12	0.145	0.219	2.349	3.104	.	.	.	.	.	.	.	.	.	.	.
P13	0.136	0.198	1.727	2.209	2.823	.	.	.	.	.	.	.	.	.	.
P14	0.134	0.192	1.330	2.210	2.034	1.470	.	.	.	.	.	.	.	.	.
P15	0.131	0.188	0.571	1.862	1.732	0.807	2.665	.	.	.	.	.	.	.	.
P16	0.129	0.184	-0.983	1.887	1.610	0.588	1.883	2.208	.	.	.	.	.	.	.
P17	0.125	0.171	-0.505	1.456	1.415	0.728	0.712	1.820	3.193	.	.	.	.	.	.
P18	0.122	0.168	-0.516	1.481	1.215	0.533	0.276	1.426	2.227	1.985	.	.	.	.	.
P19	0.118	0.154	-0.904	1.381	1.041	0.803	0.703	0.602	1.573	1.758	1.711	.	.	.	.
P20	0.086	0.076	0.344	0.701	0.965	0.539	1.035	1.357	0.881	1.678	0.988	1.091	.	.	.
P21	0.061	0.041	0.994	0.508	0.691	0.796	0.735	1.173	0.792	1.146	0.925	0.640	1.372	.	.
P22	0.039	0.016	1.142	0.562	0.700	0.745	1.010	0.779	0.752	0.874	0.560	0.732	0.647	1.544	.
P23	0.029	0.007	1.198	0.561	0.777	0.755	0.770	1.005	0.484	0.833	0.607	0.715	0.560	0.975	1.098

NOTE: Results for only modes are presented only for modes 11 through 23. Mode 11 is the first mode of Phase 2 and if the 24^{th} mode is completed the actual IM240 full or composite score would be used rather than the predicted score.

Composite IM240 HC Regression Coefficients Developed from Modal IM240 Data Analysis
1985-1989 Model Year Light-Duty Gasoline Vehicles
0.8 g/mi Cutpoint

			Regression Coefficients																						
Mode	RMS Error	Const	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
M1	0.301	0.430	5.602	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M2	0.248	0.259	0.159	3.044	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M3	0.242	0.255	-0.183	2.108	2.824	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M4	0.224	0.223	0.012	1.015	0.555	3.864	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M5	0.219	0.212	-0.084	1.168	-0.763	2.919	3.395	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M6	0.207	0.189	0.424	0.758	-0.026	0.591	1.742	4.092	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M7	0.194	0.181	0.649	0.668	-0.372	0.443	1.314	1.053	3.066	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M8	0.184	0.169	0.369	0.880	-0.438	0.037	1.302	1.440	0.797	2.830	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M9	0.174	0.157	0.342	0.927	-0.266	-0.055	1.335	1.391	0.656	0.035	4.534	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M10	0.171	0.154	0.180	1.101	-0.631	0.068	0.949	1.233	0.822	-0.082	3.332	2.217	.	.	.	.	.	.	.	.	.	.	.	.	.
M11	0.167	0.150	-0.536	1.168	-0.318	-0.082	0.705	1.264	0.846	-0.127	3.103	1.373	4.334	.	.	.	.	.	.	.	.	.	.	.	.
M12	0.144	0.106	0.170	0.593	0.221	0.266	0.883	0.515	0.448	0.428	1.462	1.314	1.001	2.829	.	.	.	.	.	.	.	.	.	.	.
M13	0.137	0.095	0.153	0.601	0.146	0.360	0.542	0.548	0.519	0.277	1.402	1.109	1.248	2.159	2.122	.	.	.	.	.	.	.	.	.	.
M14	0.135	0.091	0.169	0.583	0.126	0.499	0.226	0.547	0.530	0.265	1.482	0.760	1.225	2.183	1.358	1.490	.	.	.	.	.	.	.	.	.
M15	0.131	0.089	0.272	0.609	0.139	0.358	0.572	0.388	0.544	0.195	1.174	0.605	0.985	1.914	1.217	0.696	2.684	.	.	.	.	.	.	.	.
M16	0.129	0.087	0.278	0.683	0.092	0.322	0.166	0.487	0.671	0.212	1.115	0.457	-0.039	1.831	1.143	0.626	1.714	2.124	.	.	.	.	.	.	.
M17	0.125	0.081	0.348	0.641	0.274	0.241	0.418	0.209	0.775	0.207	0.887	0.657	0.145	1.602	0.944	0.500	0.969	1.584	2.648	.	.	.	.	.	.
M18	0.122	0.080	0.348	0.651	0.147	0.387	0.291	0.439	0.622	0.115	0.812	0.631	0.217	1.651	0.809	0.246	0.548	1.358	1.605	1.837	.	.	.	.	.
M19	0.116	0.070	0.355	0.591	0.583	0.180	0.199	0.559	0.697	0.082	0.426	1.018	-0.368	1.511	0.738	0.346	0.826	0.523	1.293	1.374	1.818	.	.	.	.
M20	0.085	0.029	0.432	0.465	0.545	0.443	0.311	0.226	0.677	0.359	0.604	1.148	0.387	0.555	0.731	0.187	1.034	0.908	0.755	1.211	0.916	0.953	.	.	.
M21	0.055	0.018	0.542	0.524	0.385	0.537	0.398	0.546	0.373	0.556	0.462	1.214	0.466	0.368	0.484	0.520	0.679	0.708	0.564	0.703	0.808	0.426	1.126	.	.
M22	0.035	0.009	0.575	0.503	0.544	0.511	0.339	0.596	0.434	0.512	0.371	1.085	0.490	0.400	0.498	0.500	0.819	0.484	0.555	0.610	0.493	0.533	0.467	1.096	.
M23	0.024	0.004	0.574	0.499	0.516	0.525	0.455	0.493	0.482	0.528	0.353	0.981	0.668	0.420	0.558	0.534	0.542	0.577	0.422	0.576	0.522	0.504	0.427	0.599	0.842

NOTE: Results for only 23 modes are shown here because if the 24th mode is completed the actual IM240 score would then be used rather than the predicted score.

Phase 2 IM240 HC Regression Coefficients Developed from Modal IM240 Data Analysis
1985-1989 Model Year Light-Duty Gasoline Vehicles
0.5 g/mi Cutpoint

			Regression Coefficients												
Mode Number	RMS Error	Reg. Const.	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
P11	0.177	0.259	9.328	.	.	.	.	.	.	.	.	.	.	.	.
P12	0.140	0.150	2.179	3.452	.	.	.	.	.	.	.	.	.	.	.
P13	0.132	0.131	1.779	2.527	2.741	.	.	.	.	.	.	.	.	.	.
P14	0.129	0.125	1.374	2.545	1.628	1.888	.	.	.	.	.	.	.	.	.
P15	0.125	0.121	0.861	2.070	1.387	1.001	2.991	.	.	.	.	.	.	.	.
P16	0.123	0.119	-0.368	2.053	1.269	0.818	2.160	2.195	.	.	.	.	.	.	.
P17	0.118	0.109	0.059	1.736	1.014	0.823	1.032	1.762	3.119	.	.	.	.	.	.
P18	0.115	0.107	-0.009	1.760	0.833	0.559	0.556	1.401	2.128	2.030	.	.	.	.	.
P19	0.109	0.094	-0.526	1.622	0.698	0.823	0.762	0.636	1.569	1.573	2.175	.	.	.	.
P20	0.077	0.041	0.637	0.716	0.900	0.635	1.081	1.205	1.005	1.455	1.267	1.123	.	.	.
P21	0.057	0.025	0.945	0.562	0.700	0.868	0.834	1.063	0.867	0.971	1.063	0.658	1.363	.	.
P22	0.037	0.013	0.917	0.590	0.738	0.748	1.105	0.785	0.740	0.839	0.583	0.740	0.631	1.554	.
P23	0.027	0.006	1.052	0.609	0.774	0.810	0.757	0.906	0.536	0.802	0.675	0.711	0.575	0.903	1.137

NOTE: Results for only modes are presented only for modes 11 through 23. Mode 11 is the first mode of Phase 2 and if the 24^{th} mode is completed the actual IM240 full or composite score would be used rather than the predicted score.

Composite IM240 HC Regression Coefficients Developed from Modal IM240 Data Analysis
1990+ Model Year Light-Duty Gasoline Vehicles
0.8 g/mi Cutpoint

			Regression Coefficients																						
Mode	RMS Error	Const.	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
M1	0.368	0.162	10.855	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M2	0.271	0.028	0.252	4.621	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M3	0.253	0.036	0.096	2.693	4.788	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M4	0.230	0.031	0.720	0.868	1.740	4.997	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M5	0.221	0.026	0.391	1.110	0.060	3.325	5.174	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M6	0.207	0.021	0.862	0.623	1.005	0.397	2.743	5.132	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M7	0.192	0.025	1.279	0.372	0.699	0.393	2.028	1.127	3.732	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M8	0.175	0.030	1.076	0.515	0.477	0.150	1.178	1.750	0.608	3.725	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M9	0.162	0.032	1.111	0.490	0.510	0.142	1.351	1.370	0.587	0.494	5.180	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M10	0.155	0.034	0.742	0.835	-0.133	0.470	0.754	0.829	0.980	0.287	3.033	3.511	.	.	.	.	.	.	.	.	.	.	.	.	.
M11	0.149	0.037	-0.292	0.916	0.270	0.141	0.342	0.923	1.049	0.326	2.661	2.172	5.629	.	.	.	.	.	.	.	.	.	.	.	.
M12	0.123	0.028	0.433	0.321	0.650	0.528	0.818	-0.003	0.245	1.037	0.672	2.127	1.234	3.583	.	.	.	.	.	.	.	.	.	.	.
M13	0.115	0.025	0.578	0.296	0.562	0.394	0.374	0.234	0.492	0.715	0.629	1.553	1.271	2.743	2.839	.	.	.	.	.	.	.	.	.	.
M14	0.113	0.025	0.618	0.262	0.555	0.503	-0.034	0.227	0.569	0.714	0.776	1.121	1.069	2.758	1.607	2.069	.	.	.	.	.	.	.	.	.
M15	0.107	0.027	0.747	0.284	0.574	0.244	0.529	0.033	0.676	0.571	0.487	1.011	0.912	2.369	1.258	0.591	3.362	.	.	.	.	.	.	.	.
M16	0.102	0.027	0.719	0.462	0.356	0.136	0.065	0.303	0.778	0.668	0.345	0.659	-0.008	2.189	1.033	0.401	2.153	2.766	.	.	.	.	.	.	.
M17	0.098	0.026	0.794	0.426	0.518	0.062	0.242	0.168	0.786	0.737	0.079	0.882	0.127	1.928	0.726	0.488	1.245	1.994	2.960	.	.	.	.	.	.
M18	0.095	0.026	0.769	0.455	0.367	0.197	0.174	0.420	0.710	0.561	0.016	0.870	0.128	2.015	0.442	0.256	0.759	1.521	1.733	2.083	.	.	.	.	.
M19	0.090	0.023	0.816	0.385	0.654	0.080	0.083	0.642	0.717	0.557	-0.358	1.269	-0.488	1.916	0.340	0.282	0.819	0.888	1.357	1.477	1.846	.	.	.	.
M20	0.068	0.009	0.575	0.360	0.539	0.382	0.257	0.458	0.639	0.556	0.034	1.205	0.514	0.804	0.472	0.255	0.693	1.266	0.881	1.203	0.837	1.073	.	.	.
M21	0.041	0.007	0.544	0.483	0.489	0.528	0.539	0.520	0.388	0.588	0.284	1.157	0.523	0.367	0.461	0.575	0.548	0.853	0.677	0.674	0.583	0.370	1.309	.	.
M22	0.027	0.003	0.559	0.500	0.535	0.538	0.444	0.602	0.406	0.514	0.284	0.992	0.497	0.407	0.518	0.526	0.656	0.637	0.661	0.573	0.470	0.497	0.525	1.112	.
M23	0.019	0.002	0.553	0.496	0.515	0.537	0.525	0.518	0.438	0.535	0.349	0.870	0.650	0.429	0.549	0.567	0.521	0.624	0.554	0.536	0.443	0.510	0.387	0.654	0.853

NOTE: Results for only 23 modes are shown here because if the 24th mode is completed the actual IM240 score would then be used rather than the predicted score.

Phase 2 IM240 HC Regression Coefficients Developed from Modal IM240 Data Analysis
1990+ Model Year Light-Duty Gasoline Vehicles
0.5 g/mi Cutpoint

			Regression Coefficients												
Mode Number	RMS Error	Reg. Const.	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23
P11	0.153	0.098	13.195	.	.	.	.	.	.	.	.	.	.	.	.
P12	0.114	0.048	3.112	4.074	.	.	.	.	.	.	.	.	.	.	.
P13	0.102	0.041	1.873	2.680	3.765	.	.	.	.	.	.	.	.	.	.
P14	0.099	0.039	1.406	2.668	2.167	2.454	.	.	.	.	.	.	.	.	.
P15	0.095	0.040	1.107	2.141	1.738	1.122	3.342	.	.	.	.	.	.	.	.
P16	0.091	0.040	-0.030	2.065	1.365	0.858	2.119	3.157	.	.	.	.	.	.	.
P17	0.088	0.038	0.165	1.791	1.043	0.931	1.028	2.401	3.357	.	.	.	.	.	.
P18	0.085	0.038	0.093	1.843	0.719	0.663	0.610	1.854	2.189	2.206	.	.	.	.	.
P19	0.081	0.035	-0.272	1.779	0.514	0.829	0.678	1.356	1.669	1.515	1.952	.	.	.	.
P20	0.057	0.016	0.581	0.846	0.727	0.616	0.627	1.840	1.313	1.345	0.856	1.195	.	.	.
P21	0.040	0.010	0.817	0.585	0.723	0.936	0.588	1.434	1.014	0.886	0.731	0.623	1.512	.	.
P22	0.028	0.005	0.823	0.606	0.751	0.837	0.740	1.015	0.843	0.855	0.581	0.717	0.749	1.426	.
P23	0.020	0.003	0.909	0.612	0.790	0.837	0.609	0.957	0.714	0.775	0.632	0.719	0.591	0.868	1.158

NOTE: Results for only modes are presented only for modes 11 through 23. Mode 11 is the first mode of Phase 2 and if the 24th mode is completed the actual IM240 full or composite score would be used rather than the predicted score.

Appendix E

Calculation of Raw Emission Scores from Dilute Measurements

Calculation of Raw Emission Scores from Dilute Measurements

The constant volume sampling technique, which has been part of the FTP for the exhaust emissions testing of passenger cars and light-duty trucks since the 1972 model year, involves the collection of a sample of exhaust gas after it has been diluted to a known, constant volume. Using this procedure, a device called a "constant volume sampler" dilutes the vehicle exhaust and then samples a constant volume fraction of the dilute mixture. In a typical test facility, the dilution is achieved by drawing "background" air from the room where the vehicle is being driven on a chassis dynamometer. A slipstream from the diluted exhaust is pumped into a series of sample bags during the test. Three sample bags are used for dilute exhaust samples: the first represents the "cold start" phase of the test, the second represents "stabilized" operation, and the third represents the "hot start" phase of the test. Samples of background air are simultaneously collected in three additional bags. At the end of the test, measurement of the concentration of pollutants in the sample bags and calculation of the total flow of the dilute mixture during each phase allows the mass of emissions emitted during each phase of the test to be calculated. Division of the calculated mass by the associated driving distance provides the mass emissions rate (normally expressed in grams per mile).

A variation of the FTP test procedure is used in CVS-based I/M testing. Instead of filling sample bags with dilute mixture during separate phases of the test, the concentrations of pollutants in the dilute exhaust stream are continuously monitored. Mass emissions per mile of travel are calculated from integration of the continuous measurements divided by the distance driven during the test. (This technique facilitates the use of "fast pass" and "fast fail" algorithms for shortening the test in cases where a vehicle is extremely clean or extremely dirty during the early portion of the test.)

In CVS-based testing, the volume of background (dilution) air in the sample substantially exceeds the volume of exhaust gas, usually by a factor of ten or more. As a result, the extent to which the dilution air is contaminated with pollutants can significantly affect the calculated mass emissions. To eliminate this interference, the extent to which the vehicle exhaust has been diluted must be known. The FTP specifies that the ratio of total volume to exhaust volume ("dilution factor") be calculated using the following equation:

$$[1]\quad DF_{EPA} = \frac{13.4}{CO_{2e} + CO_e + HC_e}$$

where: CO_{2e}, CO_e, and HC_e are the concentrations measured in the dilute sample expressed as percent volume.

In the above equation, the DF calculated in accordance with the FTP is specified as "DF_{EPA}" to distinguish it from an improved formulation of the DF discussed below. As noted above, DF_{EPA} is used in the FTP to correct the emissions concentration in the sample bag for pollutants in the dilution (background) air. Although not required by the FTP, the average DF can also be used to calculate the average concentration of the undiluted tailpipe emissions emitted while the sample bag was being filled. If there were no pollutants in the dilution air, the tailpipe concentrations could be calculated simply by multiplying the dilute measurement by the DF:

$$[2]\ Ctp = Cconc * DF$$

where: Ctp is the actual raw tailpipe concentration, and Cconc is the concentration of a pollutant in the dilute sample defined as:

$$[3]\ C_{conc} = C_e - C_d\left(1 - \frac{1}{DF}\right)$$

where Ce is the pollutant dilute concentration and Cd is the pollutant background concentration.

Substituting [3] into [2] yields:

$$[4]\quad Ctp = \left[Ce - Cd\left(1 - \frac{1}{DF}\right)\right]DF$$

As noted above, the CVS technique used to measure emissions in I/M programs involves calculating mass emissions by integrating the continuously monitored dilute sample. An average dilution factor can still be calculated from the integrated average of the dilute emissions. The DF can also be calculated continuously and used to calculate the undiluted tailpipe concentration at any point in time. This capability makes it possible to use the CVS emissions measurement system to determine whether a vehicle meets emissions standards that are based on tailpipe concentrations. If, for example, a CO concentration of 0.1% is measured in the dilute exhaust stream, and if the calculated DF is 10, then the tailpipe emission concentration would be calculated to be 1.0% CO (assuming background concentrations were zero).

Although there are several advantages associated with the use of the reverse dilution calculation method, some error is introduced in the calculation of the tailpipe concentration due to the discrepancies that can exist between actual test conditions and the assumptions on which the standard DF calculation is based. As described in detail in a previously referenced technical paper (SAE paper 980678), the DF equation contained in the FTP is based on three assumptions:

1. Exhaust emissions of vehicles are the product of a chemically balanced (i.e., stoichiometric) ratio of air and fuel;
2. The concentrations of pollutants in the background air have an insignificant effect on the calculation of the DF; and
3. No water vapor has been removed from the sample.

Each of these assumptions is problematic when the reverse dilution technique is used to calculate the concentration of pollutants in a vehicle tailpipe that would otherwise be measured directly in an I/M program. First, although most vehicles run very close to a stoichiometric air-fuel ratio, this is not always the case. Second, in the environment of an I/M test lane, pollution in the background air can be significant. Third, analyzers routinely used for raw exhaust measurement remove a substantial amount of water from the sample.[3]

A more complicated expression of the DF is required to address the limitations of the DF equation contained in the FTP. The recommended equation is as follows:[4]

$$DF = \frac{100 - K_1(CO_{2d}) - K_2(CO_d) - K_3(HC_d)}{K_1(CO_{2e} - CO_{2d}) + K_2(CO_e - CO_d) + K_3(HC_e - HC_d)}$$

where: K_1, K_2, and K_3 are constants that depend on the fuel type (see below);
CO_{2d} is the concentration of CO_2 in the background air;
CO_d is the concentration of CO in the background air;
HC_d is the concentration of HC in the background air;
CO_{2e} is the concentration of CO_2 in the dilute sample;
CO_e is the concentration of CO in the dilute sample; and
HC_e is the concentration of HC in the dilute sample.

All of the concentrations in the above equation are expressed in volume percent. The HC values are expressed in hexane equivalent. The values of K_1, K_2, and K_3 depend on the type of fuel and whether the calculated pollutant concentrations are on a wet or dry basis. When attempting to match measurements that would be made by typical systems for raw exhaust measurement, the values for dry exhaust should be used. For gasoline fuel with pollutant concentrations measured on a wet basis, such as in IM240 set-ups, the value of K_1 is 6.5431, the value for K_2 is 4.6561, and the value of K_3 is 57.0945.

Dilution Correction of Tailpipe Measurements

As noted earlier, one of the problems associated with I/M standards based on maximum allowable tailpipe concentrations is that certain causes of dilution (e.g., air injection,[5] exhaust leaks, or inadequate sample probe insertion

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[3]So-called "BAR90" analyzers actually use a condensate removal system to dispose of the water that condenses when raw exhaust is drawn through the sample probe; however, the efficiency of water removal depends on the temperature of the exhaust sample because no temperature control is provided by the analyzer.

[4]The DF equation in the previously referenced SAE paper is based on the simplifying assumption that there is no residual oxygen in the exhaust of stoichiometric or richer air-fuel mixtures. This assumption holds unless there is substantial misfire. In the case of misfire, the exhaust may contain oxygen that dilutes the concentration of other constituents. Equation 4 is a refinement of the equation contained in the SAE paper that accounts for misfire.

[5]Air injection can reduce mass emissions by facilitating more complete combustion in either the exhaust manifold or the catalytic converter. However, the dilution associated with air injection causes the measured concentration to be

depth) may cause measured concentrations to be substantially lower than for another vehicle with identical mass emissions. Because of this problem, EPA guidance for concentration measurement during simple I/M tests specifies that the sum of CO plus CO_2 emissions should be at least 6% in order for the test to be considered valid. Although the basis for the recommendation is not documented, it appears to represent the maximum level of exhaust dilution that might be expected with a relatively high output air injection system installed on a relatively small engine. As a result, it allows the exhaust concentration to be reduced by more than 50% due to various sources of dilution.[6] It is therefore a relatively ineffective means of preventing exhaust dilution from affecting the results of an I/M test.

Recently, the California Bureau of Automotive Repair (BAR) devised an improved procedure for eliminating the effects of exhaust dilution. BAR's procedure uses equations developed from basic combustion chemistry to determine the extent to which an exhaust sample must have been diluted before a concentration measurement was made. The measured concentrations are adjusted to what they would be under stoichiometric conditions with no dilution air from any source (including leaner than stoichiometric operation). BAR's exhaust dilution correction essentially involves the application of a dilution factor to the concentrations measured at the tailpipe. As described in Sierra's SAE paper, BAR's method is more sophisticated than the DF calculation incorporated into the FTP because it accounts for variations in air-fuel ratio. However, the BAR procedure ignores the effects of background air, which is not a factor during tailpipe measurements. As the SAE paper illustrates, Sierra's recommended DF equation incorporates the same basic dilution correction used by BAR in combination with a correction for pollutants in the background air. When correcting tailpipe concentrations for dilution, where no background air is involved, Sierra's DF calculation and BAR's dilution adjustment produce the same result.

Recognizing the advantages of BAR's new dilution correction procedure, EPA has incorporated it in Guidance to states on Acceleration Simulation Mode (ASM) testing. Although BAR's procedure is equally applicable to other tests that rely on concentration measurement, it has not yet been incorporated into revised guidance for idle, 2500 rpm, and other steady-state tests. However, when CVS testing is used in combination with Sierra's recommended reverse dilution calculation procedure, the effect is similar to using BAR's dilution correction.

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reduced by more than the true reduction in mass emissions.

[6] With measurement systems that remove water, and for an engine running a stoichiometric, a 6% sum of CO and CO_2 represents each part exhaust being diluted with 1.5 parts air.

Appendix F

Modal Analysis of Second-by-Second Data Preconditioning Guidelines

Developed by Sierra Research
Contract 68-C4-0056 Work Assignment 2-04

Modal Analysis of Second-by-Second Data Preconditioning Guidelines

Developed by Sierra Research
Contract 68-C4-0056 Work Assignment 2-04

Using the replicate IM240 data collected by Gordon-Darby, it was possible, through trial and error, to identify criteria to determine whether a vehicle failing an initial IM240 is inadequately preconditioned and should be tested again. This analysis was performed for each pollutant individually, and then for all pollutants combined. The analysis included 283 LDVs and 83 LDTs. The evaluation followed a step-wise progression in which the aim was to maximize the identification of vehicles that could benefit from a second test, while minimizing testing of vehicles likely to fail a second test. Recommendations for passenger cars are summarized below. A similar set of conditions was also developed for light-duty trucks, which are subject to different IM240 standards than passenger cars.

<u>IM240 Retest Criteria for Passenger Cars</u>

HC Failures **-** If PPmHC209-214 is less than 1,500, a retest is recommended if any of the following occur:

1. Phase 2 HC < 0. 8 g/mi; or
2. $massHC_{175-199}$ < 0.2 g; or
3. ($ppmHC_{75-80}$/$ppmHC_{214}$) > 4.0

For vehicles failing only HC, the following additional constraints are required for a vehicle to be retested:

1. Mass $HC_{175-199}$<0.3g and ($ppmHC_{75-80}$/$ppmHC_{209-214}$)>1.5;or
2. Mass $HC_{175-199}$ < 0.3g and Phase 2 HC < 1.0 g/mi

CO Failures **-** For CO failures, the above criteria for HC are recommended. In addition, the following constraints are recommended:

1. do not retest if Phase 2 CO > 20 g/mi <u>and</u> (Phase 1 CO/Phase 2 CO) <2; and
2. if the vehicle fails both HC and CO, retest if Mass $HC_{175-199}$ <0.3 g and mass $CO_{175-199}$ < 5.0 g.

If the vehicle is a CO-only failure, then a vehicle would benefit from a retest if:

1. Mass $CO_{175-199}$ < 6.0 g; or
2. ($ppmCO_{75-80}$/$ppmCO_{209-214}$) > 4.0; or
3. Mass $CO_{175.199}$ < 10 g and (Phase I CO > 0.75 x Phase 2 CO).

NOx Failures **-** For vehicles failing HC or CO and NOx, a retest is recommended if the following condition occurs:

1. Mass $NOx_{175-199}$ = 1.0g

For <u>NOx Only failures,</u> retest is recommended if the following criteria are met:

1. Mass NOx_{175199}<9; or
2. Mass $NOx_{175-199}$<1.l and($ppmNOx_{40-45}/ppmNOx_{209-215}$)>1.5;or
3. IM240 NOx<2.2 and ($ppmNOx_{40-45}/ppmNOx_{209-215}$)> 1.0

Multiple Pollutants **-** For multiple pollutant failures, a retest is eliminated under the following conditions:

1. the vehicle fails for all pollutants; or
2. the vehicle fails HC and CO and (Phase 2 CO > 20 g/mi and mass $CO_{175-199}$ >6.0 g); or
3. the vehicle fails HC and NOx and ($ppmHC_{209-214}$ >1,200) or ($ppmNOx_{209-214}$ > 1,200

<u>IM240 Retest Criteria for Light-Duty Trucks</u>

Because they are subject to different numerical IM240 emission standards, a different set of retest criteria were developed for light-duty trucks. These criteria are similar to those established for passenger cars, with adjustments to account for standards differences.

HC Failures **-** For <u>1981 to 1983</u> model year vehicles, if $ppmHC_{209-214}$ < 2,000 and any of the following conditions exist, then a retest is recommended:

1. Phase 2 HC < 3.0 g/mi; or
2. Mass $HC_{175-199}$ < 0.8 g; or
3. ($ppmHC_{75-80}/ppmHC_{209-214}$)>4.0

In addition, if the full IM240 is less than 3.5 g/mi HC (regardless of the value of $ppmHC_{209-214}$), then a retest is recommended.

For 1984 <u>and later</u> model year vehicles, if $ppmHC_{209-214}$<1,500 and any of the following conditions exist a retest is recommended:

1. Phase 2 HC< 2.0 g/mi; or
2. $MassHC_{175-199}$ < 0.4 g; or
3. ($ppmHC_{75-80}/ppmHC_{209-214}$)>4.0

In addition, if 0.4<Mass $HC_{175-199}$<0.8 and ($ppmHC_{75-80}/ppmHC_{209-214}$)>2.0 (regardless of the value of $ppmHC_{209-214}$) then a retest is recommended.

A retest <u>is not recommended</u> if Phase 2 HC > 3.2 g/mi.

CO Failures **-** For CO failures, the above criteria outlined for HC were also used. In addition, the following conditions were also imposed to cut down on the number of vehicles incorrectly identified as needing a retest:

1. If 1981 to 1983 model year and Mass $CO_{175-199}$>36g then do not retest.
2. If 1984 or later model year and Mass $CO_{175-199}$>18g then do not retest.
3. If Phase 2 CO>40 and Phase 2 CO > Phase I CO then do not retest.

NOx Failures **-** If the vehicle failed NOx and either HC or CO, the above criteria were used to determine the need for a retest. For LDT1&2s, if the vehicle failed only NOx. then a retest is recommended if Mass $NOx_{l75-199}$ < 1.4 g. For 1988 and later LDT3&4s, a retest is recommended only if Mass $NOx_{175-199}$ < 2.5 g.

Appendix G

Full and Fast-Pass IM240 Positive Kinetic Energy Speed Variation Limits

Developed by Sierra Research
Contract 68-C4-0056

Full and Fast-Pass IM240 Positive Kinetic Energy Speed Variation Limits

Developed by Sierra Research
Contract 68-C4-0056

Evaluation of Alternative Statistical Measures

Based upon similar work conducted by the New York Automotive Emissions Laboratory (AEL,)[7] two easily determined, alternative statistical metrics were evaluated for their ability to identify and quantify IM240 speed variations that significantly affect emissions:

(1). DPWRSUM - the sum of absolute changes in specific power; and

(2). Positive Kinetic Energy (PKE) - the sum of positive differences in kinetic energy per unit distance.

Each of these metrics are explained in more detail below.

DPWRSUM - Specific power is defined as power per unit mass, which can be restated as follows:

$$\text{Specific Power} = \frac{\text{power}}{\text{mass}} = \frac{\text{work}}{\text{mass} \times \Delta\text{time}} = \frac{\Delta\text{kinetic energy}}{\text{mass} \times \Delta\text{time}} = \frac{\frac{1}{2} \times \text{mass} \times \Delta V^2}{\text{mass} \times \Delta\text{time}}$$

Over a transient driving cycle of second-by-second speeds, EPA defines the specific power P at any time t (and dropping the factor of ½) as:

$$P_t = V_t^2 - V_{t-1}^2$$

The absolute difference in specific power at time t can then be written as:

$$DP_t = \left|P_t - P_{t-1}\right| = \left|V_t^2 - 2 V_{t-1}^2 + V_{t-2}^2\right|$$

The DPWRSUM statistic then is defined over a cycle of N seconds as:

[7] W. J. Webster and C. Shih, "A Statistically Derived Metric to Monitor Time-Speed Variability in Practical Emissions Testing," New York State Department of Environmental Conservation, presented at the 6th CRC On-Road Vehicle Emissions Workshop, March 18-20, 1996.

$$DPWRSUM = \sum_{t=0}^{N} DP_t = \sum_{t=0}^{N} \left| V_t^2 - 2\,V_{t-1}^2 + V_{t-2}^2 \right|$$

PKE - Positive Kinetic Energy has been defined mathematically as:

$$PKE = \frac{\sum_{t=0}^{N} PP_t}{\int_0^x dx}$$

over a traveled driving cycle of distance x where PP is the positive specific power and is given by the following expression when $V_t > V_{t-1}$, and is zero when $V_t \leq V_{t-1}$.

$$PP_t = V_t^2 - V_{t-1}^2$$

Each of these metrics can be easily computed from the second-by-second speed measurements collected in IM240 testing. In comparing their relative ability to identify speed variations that produce high emissions, it is helpful to consider which speed variations contribute to the value of each metric (similar to the earlier examination of the SE statistic) over an IM240 test.

Note that although both DPWRSUM and PKE are affected by differences in specific power or squared speeds over "adjacent" seconds of an IM240 trace, the value of DPWRSUM is increased during decelerations as well as accelerations. PKE on the other hand, is only increased during acceleration periods.

IM240 REFERENCE DATA			PKE VARIATION CUTPOINTS (miles/hr2)				
		CUM PKE	"BASE "	MULT.	VARYING	CUMULATIVE PKE	
TIME	SPEED	(miles/hr2)	DELTA	FACTO R	DELTA	LOW	HIGH
0	0.0	0.0	.	.	.	.	.
1	0.0	0.0	.	.	.	.	.
2	0.0	0.0	.	.	.	.	.
3	0.0	0.0	.	.	.	.	.
4	0.0	0.0	.	.	.	.	.
5	3.0	10,800.0	.	.	.	.	.
6	5.9	14,080.4	.	.	.	.	.
7	8.6	15,214.6	.	.	.	.	.
8	11.5	16,417.2	.	.	.	.	.
9	14.3	17,001.5	.	.	.	.	.
10	16.9	17,079.7	.	.	.	.	.
11	17.3	13,902.5	.	.	.	.	.
12	18.1	12,336.8	.	.	.	.	.
13	20.7	13,263.7	.	.	.	.	.
14	21.7	12,284.1	.	.	.	.	.
15	22.4	11,261.4	.	.	.	.	.
16	22.5	9,964.5	.	.	.	.	.
17	22.1	8,890.2	.	.	.	.	.
18	21.5	8,046.4	.	.	.	.	.
19	20.9	7,366.6	.	.	.	.	.
20	20.4	6,805.5	.	.	.	.	.
21	19.8	6,336.9	.	.	.	.	.
22	17.0	5,983.3	.	.	.	.	.
23	14.9	5,704.2	.	.	.	.	.
24	14.9	5,450.1	.	.	.	.	.
25	15.2	5,306.1	.	.	.	.	.
26	15.5	5,171.6	.	.	.	.	.
27	16.0	5,103.3	.	.	.	.	.
28	17.1	5,213.3	.	.	.	.	.
29	19.1	5,599.3	.	.	.	.	.
30	21.1	5,990.0	342.3	4.000	1,369.3	4,621	7,359
31	22.7	6,242.3	356.7	3.986	1,421.8	4,820	7,664
32	22.9	6,014.8	343.7	3.971	1,365.1	4,650	7,380
33	22.7	5,745.3	328.3	3.957	1,299.3	4,446	7,045
34	22.6	5,500.0	314.3	3.943	1,239.3	4,261	6,739
35	21.3	5,287.2	302.2	3.929	1,187.0	4,100	6,474
36	19.0	5,110.8	292.1	3.914	1,143.3	3,968	6,254
37	17.1	4,961.9	283.6	3.900	1,105.9	3,856	6,068

38	15.8	4,831.8	276.1	3.886	1,072.9	3,759	5,905
39	15.8	4,708.3	269.1	3.871	1,041.7	3,667	5,750
40	17.7	4,937.5	282.2	3.857	1,088.4	3,849	6,026
41	19.8	5,220.8	298.4	3.843	1,146.5	4,074	6,367
42	21.6	5,450.3	311.5	3.829	1,192.5	4,258	6,643
43	23.2	5,638.2	322.2	3.814	1,229.0	4,409	6,867
44	24.2	5,685.3	324.9	3.800	1,234.6	4,451	6,920
45	24.6	5,592.5	319.6	3.786	1,209.9	4,383	6,802
46	24.9	5,481.7	313.3	3.771	1,181.5	4,300	6,663
47	25.0	5,332.7	304.8	3.757	1,145.0	4,188	6,478
48	25.7	5,321.5	304.1	3.743	1,138.2	4,183	6,460
49	26.1	5,245.9	299.8	3.729	1,117.8	4,128	6,364
50	26.7	5,216.3	298.1	3.714	1,107.2	4,109	6,323
51	27.5	5,230.2	298.9	3.700	1,105.9	4,124	6,336
52	28.6	5,307.9	303.3	3.686	1,118.0	4,190	6,426
53	29.3	5,298.0	302.8	3.671	1,111.6	4,186	6,410
54	29.8	5,246.1	299.8	3.657	1,096.4	4,150	6,343
55	30.1	5,155.0	294.6	3.643	1,073.2	4,082	6,228
56	30.4	5,068.3	289.6	3.629	1,051.0	4,017	6,119
57	30.7	4,985.6	284.9	3.614	1,029.8	3,956	6,015
58	30.7	4,848.3	277.1	3.600	997.5	3,851	5,846
59	30.5	4,719.2	269.7	3.586	967.0	3,752	5,686
60	30.4	4,597.2	262.7	3.571	938.3	3,659	5,535
61	30.3	4,481.7	256.1	3.557	911.1	3,571	5,393
62	30.4	4,389.2	250.8	3.543	888.7	3,501	5,278
63	30.8	4,352.1	248.7	3.529	877.6	3,474	5,230
64	30.4	4,250.1	242.9	3.514	853.6	3,397	5,104
65	29.9	4,154.4	237.4	3.500	831.0	3,323	4,985
66	29.5	4,064.1	232.3	3.486	809.6	3,255	4,874
67	29.8	4,022.9	229.9	3.471	798.1	3,225	4,821
68	30.3	4,013.3	229.3	3.457	792.9	3,220	4,806
69	30.7	3,988.8	228.0	3.443	784.8	3,204	4,774
70	30.9	3,935.5	224.9	3.429	771.1	3,164	4,707
71	31.0	3,869.4	221.1	3.414	755.0	3,114	4,624
72	30.9	3,791.8	216.7	3.400	736.8	3,055	4,529
73	30.4	3,718.5	212.5	3.386	719.5	2,999	4,438
74	29.8	3,649.2	208.5	3.371	703.1	2,946	4,352
75	29.9	3,595.5	205.5	3.357	689.8	2,906	4,285
76	30.2	3,569.2	204.0	3.343	681.9	2,887	4,251
77	30.7	3,569.2	204.0	3.329	678.9	2,890	4,248
78	31.2	3,569.3	204.0	3.314	676.0	2,893	4,245
79	31.8	3,582.2	204.7	3.300	675.6	2,907	4,258
80	32.2	3,569.2	204.0	3.286	670.2	2,899	4,239

81	**32.4**	**3,531.2**	**201.8**	**3.271**	**660.2**	**2,871**	**4,191**
82	**32.2**	**3,469.8**	**198.3**	**3.257**	**645.9**	**2,824**	**4,116**
83	**31.7**	**3,411.4**	**195.0**	**3.243**	**632.2**	**2,779**	**4,044**
84	**28.6**	**3,360.3**	**192.0**	**3.229**	**620.0**	**2,740**	**3,980**
85	**25.1**	**3,316.8**	**189.5**	**3.214**	**609.3**	**2,708**	**3,926**
86	**21.6**	**3,280.2**	**187.5**	**3.200**	**599.9**	**2,680**	**3,880**
87	**18.1**	**3,250.2**	**185.7**	**3.186**	**591.7**	**2,658**	**3,842**
88	**14.6**	**3,226.3**	**184.4**	**3.171**	**584.7**	**2,642**	**3,811**
89	**11.1**	**3,208.4**	**183.4**	**3.157**	**578.9**	**2,630**	**3,787**
90	**7.6**	**3,196.3**	**182.7**	**3.143**	**574.1**	**2,622**	**3,770**
91	**4.1**	**3,189.8**	**182.3**	**3.129**	**570.3**	**2,619**	**3,760**
92	**0.6**	**3,188.9**	**182.2**	**3.114**	**567.5**	**2,621**	**3,756**
93	**0.0**	**3,188.9**	**182.2**	**3.100**	**564.9**	**2,624**	**3,754**
94	**0.0**	**3,188.9**	**182.2**	**3.086**	**562.3**	**2,627**	**3,751**
95	**0.0**	**3,188.9**	**182.2**	**3.071**	**559.7**	**2,629**	**3,749**
96	**0.0**	**3,188.9**	**182.2**	**3.057**	**557.1**	**2,632**	**3,746**
97	**0.0**	**3,188.9**	**182.2**	**3.043**	**554.5**	**2,634**	**3,743**
98	**3.3**	**3,203.1**	**183.0**	**3.029**	**554.4**	**2,649**	**3,757**
99	**6.6**	**3,250.7**	**185.8**	**3.014**	**560.0**	**2,691**	**3,811**
100	**9.9**	**3,331.3**	**190.4**	**3.000**	**571.1**	**2,760**	**3,902**
101	**13.2**	**3,443.8**	**196.8**	**2.986**	**587.6**	**2,856**	**4,031**
102	**16.5**	**3,587.2**	**205.0**	**2.971**	**609.1**	**2,978**	**4,196**
103	**19.8**	**3,760.1**	**214.9**	**2.957**	**635.4**	**3,125**	**4,396**
104	**22.2**	**3,892.7**	**222.5**	**2.943**	**654.7**	**3,238**	**4,547**
105	**24.3**	**4,013.3**	**229.4**	**2.929**	**671.7**	**3,342**	**4,685**
106	**25.8**	**4,090.8**	**233.8**	**2.914**	**681.3**	**3,409**	**4,772**
107	**26.4**	**4,093.0**	**233.9**	**2.900**	**678.3**	**3,415**	**4,771**
108	**25.7**	**4,045.3**	**231.2**	**2.886**	**667.1**	**3,378**	**4,712**
109	**25.1**	**3,999.9**	**228.6**	**2.871**	**656.4**	**3,344**	**4,656**
110	**24.7**	**3,956.1**	**226.1**	**2.857**	**646.0**	**3,310**	**4,602**
111	**25.2**	**3,951.8**	**225.8**	**2.843**	**642.0**	**3,310**	**4,594**
112	**25.4**	**3,924.1**	**224.3**	**2.829**	**634.3**	**3,290**	**4,558**
113	**27.2**	**4,024.3**	**230.0**	**2.814**	**647.2**	**3,377**	**4,672**
114	**26.5**	**3,979.2**	**227.4**	**2.800**	**636.7**	**3,342**	**4,616**
115	**24.0**	**3,939.2**	**225.1**	**2.786**	**627.1**	**3,312**	**4,566**
116	**22.7**	**3,902.0**	**223.0**	**2.771**	**618.0**	**3,284**	**4,520**
117	**19.4**	**3,870.9**	**221.2**	**2.757**	**609.9**	**3,261**	**4,481**
118	**17.7**	**3,842.9**	**219.6**	**2.743**	**602.4**	**3,241**	**4,445**
119	**17.2**	**3,816.0**	**218.1**	**2.729**	**595.0**	**3,221**	**4,411**
120	**18.1**	**3,834.3**	**219.1**	**2.714**	**594.8**	**3,240**	**4,429**
121	**18.6**	**3,832.2**	**219.0**	**2.700**	**591.3**	**3,241**	**4,423**
122	**20.0**	**3,879.0**	**221.7**	**2.686**	**595.4**	**3,284**	**4,474**
123	**20.7**	**3,887.7**	**222.2**	**2.671**	**593.5**	**3,294**	**4,481**

124	21.7	3,914.4	223.7	2.657	594.4	3,320	4,509
125	22.4	3,923.5	224.2	2.643	592.6	3,331	4,516
126	22.5	3,895.8	222.6	2.629	585.2	3,311	4,481
127	22.1	3,863.1	220.8	2.614	577.1	3,286	4,440
128	21.5	3,831.7	219.0	2.600	569.3	3,262	4,401
129	20.9	3,801.8	217.3	2.586	561.8	3,240	4,364
130	20.4	3,772.9	215.6	2.571	554.4	3,219	4,327
131	19.8	3,745.4	214.0	2.557	547.3	3,198	4,293
132	17.0	3,722.1	212.7	2.543	540.9	3,181	4,263
133	17.1	3,703.4	211.6	2.529	535.1	3,168	4,239
134	15.8	3,682.2	210.4	2.514	529.1	3,153	4,211
135	15.8	3,661.2	209.2	2.500	523.1	3,138	4,184
136	17.7	3,720.0	212.6	2.486	528.4	3,192	4,248
137	19.8	3,794.6	216.9	2.471	535.9	3,259	4,330
138	21.6	3,860.2	220.6	2.457	542.1	3,318	4,402
139	22.2	3,863.3	220.8	2.443	539.3	3,324	4,403
140	24.5	3,964.6	226.6	2.429	550.2	3,414	4,515
141	24.7	3,943.1	225.3	2.414	544.0	3,399	4,487
142	24.8	3,915.9	223.8	2.400	537.1	3,379	4,453
143	24.7	3,883.2	221.9	2.386	529.4	3,354	4,413
144	24.6	3,851.1	220.1	2.371	521.9	3,329	4,373
145	24.6	3,819.6	218.3	2.357	514.5	3,305	4,334
146	25.1	3,817.5	218.2	2.343	511.1	3,306	4,329
147	25.6	3,815.4	218.0	2.329	507.7	3,308	4,323
148	25.7	3,789.6	216.6	2.314	501.2	3,288	4,291
149	25.4	3,758.6	214.8	2.300	494.0	3,265	4,253
150	24.9	3,728.8	213.1	2.286	487.1	3,242	4,216
151	25.0	3,704.9	211.7	2.271	480.9	3,224	4,186
152	25.4	3,698.2	211.3	2.257	477.0	3,221	4,175
153	26.0	3,702.8	211.6	2.243	474.6	3,228	4,177
154	26.0	3,673.1	209.9	2.229	467.8	3,205	4,141
155	25.7	3,644.1	208.3	2.214	461.1	3,183	4,105
156	26.1	3,637.9	207.9	2.200	457.4	3,181	4,095
157	26.7	3,643.0	208.2	2.186	455.0	3,188	4,098
158	27.3	3,648.1	208.5	2.171	452.7	3,195	4,101
159	30.5	3,812.6	217.9	2.157	470.0	3,343	4,283
160	33.5	3,978.0	227.3	2.143	487.1	3,491	4,465
161	36.2	4,133.0	236.2	2.129	502.8	3,630	4,636
162	37.3	4,172.3	238.4	2.114	504.1	3,668	4,676
163	39.3	4,282.5	244.7	2.100	513.9	3,769	4,796
164	40.5	4,330.6	247.5	2.086	516.2	3,814	4,847
165	42.1	4,412.1	252.1	2.071	522.3	3,890	4,934
166	43.5	4,477.8	255.9	2.057	526.4	3,951	5,004

167	**45.1**	**4,561.4**	**260.7**	**2.043**	**532.5**	**4,029**	**5,094**
168	**46.0**	**4,584.2**	**262.0**	**2.029**	**531.4**	**4,053**	**5,116**
169	**46.8**	**4,598.2**	**262.8**	**2.014**	**529.3**	**4,069**	**5,127**
170	**47.5**	**4,603.2**	**263.1**	**2.000**	**526.1**	**4,077**	**5,129**
171	**47.5**	**4,546.8**	**259.8**	**1.986**	**516.0**	**4,031**	**5,063**
172	**47.3**	**4,492.0**	**256.7**	**1.971**	**506.1**	**3,986**	**4,998**
173	**47.2**	**4,438.6**	**253.7**	**1.957**	**496.4**	**3,942**	**4,935**
174	**47.2**	**4,386.5**	**250.7**	**1.943**	**487.0**	**3,899**	**4,874**
175	**47.4**	**4,352.1**	**248.7**	**1.929**	**479.7**	**3,872**	**4,832**
176	**47.9**	**4,343.2**	**248.2**	**1.914**	**475.1**	**3,868**	**4,818**
177	**48.5**	**4,342.6**	**248.2**	**1.900**	**471.5**	**3,871**	**4,814**
178	**49.1**	**4,342.0**	**248.1**	**1.886**	**467.9**	**3,874**	**4,810**
179	**49.5**	**4,324.9**	**247.2**	**1.871**	**462.5**	**3,862**	**4,787**
180	**50.0**	**4,316.3**	**246.7**	**1.857**	**458.1**	**3,858**	**4,774**
181	**50.6**	**4,316.0**	**246.7**	**1.843**	**454.5**	**3,861**	**4,771**
182	**51.0**	**4,299.3**	**245.7**	**1.829**	**449.3**	**3,850**	**4,749**
183	**51.5**	**4,291.0**	**245.2**	**1.814**	**444.9**	**3,846**	**4,736**
184	**52.2**	**4,299.3**	**245.7**	**1.800**	**442.3**	**3,857**	**4,742**
185	**53.2**	**4,332.3**	**247.6**	**1.786**	**442.1**	**3,890**	**4,774**
186	**54.1**	**4,356.8**	**249.0**	**1.771**	**441.0**	**3,916**	**4,798**
187	**54.6**	**4,347.7**	**248.5**	**1.757**	**436.6**	**3,911**	**4,784**
188	**54.9**	**4,322.3**	**247.0**	**1.743**	**430.5**	**3,892**	**4,753**
189	**55.0**	**4,280.9**	**244.6**	**1.729**	**422.9**	**3,858**	**4,704**
190	**54.9**	**4,232.4**	**241.9**	**1.714**	**414.6**	**3,818**	**4,647**
191	**54.6**	**4,185.2**	**239.2**	**1.700**	**406.6**	**3,779**	**4,592**
192	**54.6**	**4,139.1**	**236.5**	**1.686**	**398.7**	**3,740**	**4,538**
193	**54.8**	**4,109.5**	**234.9**	**1.671**	**392.5**	**3,717**	**4,502**
194	**55.1**	**4,088.2**	**233.6**	**1.657**	**387.2**	**3,701**	**4,475**
195	**55.5**	**4,075.0**	**232.9**	**1.643**	**382.6**	**3,692**	**4,458**
196	**55.7**	**4,046.6**	**231.3**	**1.629**	**376.6**	**3,670**	**4,423**
197	**56.1**	**4,034.0**	**230.5**	**1.614**	**372.1**	**3,662**	**4,406**
198	**56.3**	**4,006.4**	**229.0**	**1.600**	**366.3**	**3,640**	**4,373**
199	**56.6**	**3,986.7**	**227.8**	**1.586**	**361.3**	**3,625**	**4,348**
200	**56.7**	**3,952.4**	**225.9**	**1.571**	**354.9**	**3,597**	**4,307**
201	**56.7**	**3,911.4**	**223.5**	**1.557**	**348.1**	**3,563**	**4,259**
202	**56.3**	**3,871.4**	**221.2**	**1.543**	**341.3**	**3,530**	**4,213**
203	**56.0**	**3,832.5**	**219.0**	**1.529**	**334.8**	**3,498**	**4,167**
204	**55.0**	**3,795.0**	**216.9**	**1.514**	**328.4**	**3,467**	**4,123**
205	**53.4**	**3,759.3**	**214.8**	**1.500**	**322.3**	**3,437**	**4,082**
206	**51.6**	**3,725.4**	**212.9**	**1.486**	**316.3**	**3,409**	**4,042**
207	**51.8**	**3,704.9**	**211.7**	**1.471**	**311.5**	**3,393**	**4,016**
208	**52.1**	**3,691.1**	**210.9**	**1.457**	**307.4**	**3,384**	**3,998**
209	**52.5**	**3,683.7**	**210.5**	**1.443**	**303.7**	**3,380**	**3,987**

210	53.0	3,682.8	210.5	1.429	300.7	3,382	3,984
211	53.5	3,682.0	210.4	1.414	297.6	3,384	3,980
212	54.0	3,681.1	210.4	1.400	294.5	3,387	3,976
213	54.9	3,705.8	211.8	1.386	293.5	3,412	3,999
214	55.4	3,704.7	211.7	1.371	290.4	3,414	3,995
215	55.6	3,684.4	210.6	1.357	285.8	3,399	3,970
216	56.0	3,677.1	210.1	1.343	282.2	3,395	3,959
217	56.0	3,644.6	208.3	1.329	276.7	3,368	3,921
218	55.8	3,612.7	206.5	1.314	271.3	3,341	3,884
219	55.2	3,581.7	204.7	1.300	266.1	3,316	3,848
220	54.5	3,551.6	203.0	1.286	261.0	3,291	3,813
221	53.6	3,522.5	201.3	1.271	255.9	3,267	3,778
222	52.5	3,494.5	199.7	1.257	251.1	3,243	3,746
223	51.5	3,467.4	198.2	1.243	246.3	3,221	3,714
224	50.5	3,441.2	196.7	1.229	241.6	3,200	3,683
225	48.0	3,416.8	195.3	1.214	237.1	3,180	3,654
226	44.5	3,394.4	194.0	1.200	232.8	3,162	3,627
227	41.0	3,374.0	192.8	1.186	228.6	3,145	3,603
228	37.5	3,355.6	191.8	1.171	224.6	3,131	3,580
229	34.0	3,339.0	190.8	1.157	220.8	3,118	3,560
230	30.5	3,324.3	190.0	1.143	217.1	3,107	3,541
231	27.0	3,311.4	189.2	1.129	213.6	3,098	3,525
232	23.5	3,300.3	188.6	1.114	210.2	3,090	3,510
233	20.0	3,290.9	188.1	1.100	206.9	3,084	3,498
234	16.5	3,283.1	187.6	1.086	203.7	3,079	3,487
235	13.0	3,277.1	187.3	1.071	200.7	3,076	3,478
236	9.5	3,272.7	187.0	1.057	197.7	3,075	3,470
237	6.0	3,269.9	186.9	1.043	194.9	3,075	3,465
238	2.5	3,268.7	186.8	1.029	192.1	3,077	3,461
239	0.0	3,268.7	186.8	1.014	189.5	3,079	3,458
Cycle Sums		3,268.7				3,079	3,458

Appendix H

Derivation of TRLHP Coefficients

Derivation of TRLHP Coefficients

(a) Road Load Equation

(1) Vehicle Loading. Road load is defined by the following equation relating track road load horsepower and vehicle velocity.

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

Where: TRLHP = Track Road Load Horsepower.

A_V, B_V, C_V = Coefficients relating TRLHP and velocity.

Obmph = Observed velocity in mph.

(2) Coefficients. A_V, B_V, and C_V are horsepower coefficients from EPA vehicle certification data or EPA default values. Coefficients shall be calculated to a minimum of five significant digits by the following equations. Power fractions determined from track coast-down data shall be calculated to a minimum of two significant digits. In the absence of new car certification coefficients, the default power fractions shall be used.

(A) $$A_v = \frac{A_v PF}{50} * (TRLHP_{@50mph}) \quad hp/mph$$

(B) $$B_v = \frac{B_v PF}{2500} * (TRLHP_{@50mph}) \quad hp/mph^2$$

(C) $$C_v = \frac{C_v PF}{125{,}000} * (TRLHP_{@50mph}) \quad hp/mph^3$$

Where: A_V, B_V, C_V = Coefficients relating TRLHP and velocity.

$A_V PF$, $B_V PF$, and $C_V PF$ are power fractions, and indicate the fraction of the total power at 50 mph contributed by each of the A_V*50, B_V*2500, and $C_V*125{,}000$ terms.

$TRLHP_{@50mph}$ = Track Road Load Horsepower at 50mph.

(D) $A_V PF + B_V PF + C_V PF = 1$

Derivation of $A_V PF$, $B_V PF$, and $C_V PF$ from known track coastdown curves shall be computed as follows:

(E) $$A_v PF = \frac{A_v * 50}{(A_v * 50) + (B_v * 2500) + (C_v * 125{,}000)}$$

(F) $$B_vPF = \frac{B_v * 2500}{(A_v * 50) + (B_v * 2500) + (C_v * 125{,}000)}$$

(G) $$C_vPF = \frac{C_v * 125{,}000}{(A_v * 50) + (B_v * 2500) + (C_v * 125{,}000)}$$

Default values:

$A_vPF = 0.35$

$B_vPF = 0.10$

$C_vPF = 0.55$

(3) TRLHP@50mph. In absence of new vehicle certification data, the 50 mph TRLHP shall be selected from the EPA I/M Look-up Table. It is based on the following equation:

$$TRLHP = \frac{\left(0.5 * ETW / 32.2\right) * (V_1^2 - V_2^2)}{550 * ET}$$

Where: ET = Elapsed time for the vehicle on the road to coast down from 55 to 45 mph

ETW = Equivalent Test Weight in pounds

V_1 = Initial velocity in feet/second

V_2 = Final velocity in feet/second

Appendix I

Derivation of GTRL Coefficients

Derivation of Dynamometer Tire/Roll Interface Losses

(a) Generic Tire Roll Loss

(1) Tire/Roll Interface Losses. Tire/roll losses include vehicle drive train losses and may be determined on a vehicle and dynamometer roll size specific basis, or using the default values presented below.

Tire losses may be characterized on a vehicle and roll size specific basis by the following equation:

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

Where: GTRL = Generic tire/roll interface losses, in horsepower.

A_t, B_t, C_t are coefficients derived by fitting a third order curve of tire losses, in horsepower, and velocity.

Obmph is the observed velocity in mph.

(A) $$A_{t8} = \frac{0.76}{50} * (GTRL_{@50mph\text{-}8}) \quad hp/mph$$

(B) $$B_{t8} = \frac{0.33}{2500} * (GTRL_{@50mph\text{-}8}) \quad hp/mph^2$$

(C) $$C_{t8} = \frac{-0.09}{125{,}000} * (GTRL_{@50mph\text{-}8}) \quad hp/mph^3$$

Where: A_{t8}, B_{t8}, C_{t8} are coefficients relating tire losses, in horsepower, and velocity on an 8.65 inch twin roll dynamometer.

0.76, 0.33, -0.09 are default 50 mph power fraction values derived from experimental data.

$GTRL_{@50mph\text{-}8} = -0.378193 + 0.0033207*DAXWT$

DAXWT = (VAXF + VAXE)/2

VAXF = Drive axle weight for a vehicle with a full fuel tank from EPA Certification database.

VAXE = Drive axle weight for a vehicle with an empty fuel tank from EPA Certification database.

(D) $$A_{t20} = \frac{0.65}{50} * (GTRL_{@50mph-20}) \quad hp/mph$$

(E) $$B_{t20} = \frac{0.48}{2500} * (GTRL_{@50mph-20}) \quad hp/mph^2$$

(F) $$C_{t20} = \frac{-0.13}{125{,}000} * (GTRL_{@50mph-20}) \quad hp/mph^3$$

Where: A_{t20}, $B_{t,20}$, C_{t20} are coefficients relating tire losses, in horsepower, and velocity on a 20 inch twin roll dynamometer.

0.65, 0.48, -0.13 are default 50 mph power fraction values derived from experimental data.

$GTRL_{@50mph-20}$ = 0.241645 + 0.0020844*DAXWT

DAXWT = (VAXF + VAXE)/2

VAXF = Drive axle weight for a vehicle with a full fuel tank from EPA Certification database.

VAXE = Drive axle weight for a vehicle with an empty fuel tank from EPA Certification database.

(2) Look-up Table. The vehicle specific values for $GTRL_{@50mph-8}$ and $GTRL_{@50mph-20}$ using default values for 50 mph power fractions are published in the latest version of the EPA I/M Look-up Table.