MAIL OUT #94-35

State of California
AIR RESOURCES BOARD

Notice of Public Availability of Modified Text

PUBLIC HEARING TO CONSIDER AMENDMENTS TO THE EMISSION CONTROL REGULATIONS FOR 1995 AND LATER MODEL UTILITY AND LAWN AND GARDEN EQUIPMENT ENGINES

Public Hearing Date: July 28, 1994
Public Availability Date: September 14, 1994
Deadline for Public Comment: September 29, 1994

At a July 28, 1994 public hearing, the Air Resources Board (ARB) considered the adoption of amendments to emission control regulations and test procedures applicable to 1995 and later model utility and lawn and garden equipment engines. Under consideration were amendments to Sections 2400-2407, Title 13, California Code of Regulations ("CCR"), and the incorporated "California Exhaust Emission Standards and Test Procedures For 1995 and Later Utility and Lawn and Garden Equipment Engines" (Test Procedures). The proposed regulatory action is described in detail in the Staff Report: Initial Statement of Reasons for Proposed Rulemaking "Public Hearing to Consider Amendments to the Emission Control Regulations For 1995 and Later Model Utility and Lawn and Garden Equipment Engines," released June 10, 1994 (Mail-out #94-24).

At the hearing, after full consideration of comments and testimony received from industry representatives, the ARB Board members approved the amendments to Sections 2400-2407, Title 13, CCR, and the Test Procedures, with modifications to the originally proposed regulatory language[1]. The modifications were developed in response to comments received by ARB staff during the 45-day comment period, and affected Sections of Title 13, CCR, as follows: Section 2400, "Applicability"; Section 2404, "Emission Control Labels - 1995 and Later Utility and Lawn and Garden Equipment Engines"; Section 2407, "New Engine Compliance and Quality-Audit Testing - New Utility and Lawn and Garden Equipment Engine Selection, Evaluation, and Enforcement Action"; and the Test Procedures. Additional modifications to the regulations have been made for purposes of consistency, grammatical correctness, and citing references correctly.

---

1. On August 29, 1994, the Executive Officer signed Executive Order G-94-051, adopting the proposed amendments to Part II, Section (11)(a)(1)(i), and Part III, Section (4)(a)(1)(i), of the Test Procedures, pertaining to petroleum-based fuels that may be used for certification testing. The ARB Board members did not propose any modifications to those sections, and the sections are not covered by this notice of availability of modified text. Rather, these sections have been forwarded to the Office of Administrative Law for separate review and approval.

utility engine regulations. The modifications clarify the applicability of the regulations to only engines produced on or after January 1, 1995, and to utility equipment that use engines produced on or after January 1, 1995.

5. Test Procedures

Part II, Section (2)(c)(3), was modified to specify that the fuel flow rate measurement instrumentation must have a combined accuracy of +/- 2 percent of the reading, instead of a minimum accuracy of +/- 1 percent of the full-scale flow rate for all power mode measurements, and +/- 5 percent for the idle-mode measurements.

6. Test Procedures

Part II, Sections (2)(d)(2)(vii) and (viii), are modified to clarify the location of the sample probe in the exhaust system. The intent is to sample a well-mixed, homogeneous gas by locating the probe in the exhaust system downstream, as applicable, of a catalytic converter, exhaust port or exhaust manifold, or the exit of a mixing chamber, and to avoid ingesting any atmospheric air that may flow back into the exhaust system. When the engine configuration requires that the sample probe be located in a muffler, the probe is to be located in the high pressure side of the muffler assembly. Figure 2-1 Engine Test Setup was modified accordingly.

7. Test Procedures

Part II, Section (5)(a), and Part III, Section (8)(a), were modified to clarify that the dynamometer is to be performance verified only as necessary.

8. Test Procedures

Part II, Section (11)(a)(2)(i)(C), and Part III, Section (4)(a)(2)(i)(C), were modified to add the provision that the Reid Vapor Pressure of service accumulation gasoline shall be characteristic of an engine fuel appropriately suited to the ambient conditions of the indoor test cell in which the service accumulation takes place. The current provision is applicable to service accumulation that occurs in the outdoors.

9. Test Procedures

Part II, Section (12)(b)(2)(ii), and Part III, Section (18)(a)(1), were modified to indicate that spark-ignition engines are recommended to be preconditioned by operating the engine at a power greater than or equal to 50 percent maximum power at rated or intermediate speed (as applicable) for 20 minutes. The current provisions specifically states that these engines "shall" be preconditioned in this manner.

ATTACHMENT I

State of California
AIR RESOURCES BOARD

Resolution 94-50
July 28, 1994

Agenda Item No.: 94-7-1

WHEREAS, section 39003 of the Health and Safety Code charges the Air Resources Board (ARB) with coordinating efforts to attain and maintain ambient air quality standards;

WHEREAS, sections 39600 and 39601 of the Health and Safety Code authorize the ARB to adopt standards, rules and regulations and to do such acts as may be necessary for the proper execution of the powers and duties granted to and imposed upon the ARB by law;

WHEREAS, in section 43000.5 of the Health and Safety Code, the Legislature found and declared that despite significant reductions in vehicle emissions in recent years, continued growth in population and vehicle miles traveled throughout California have the potential not only to prevent attainment of the state standards, but in some cases, to result in worsening of air quality;

WHEREAS, section 43013 of the Health and Safety Code authorizes the ARB to adopt standards and regulations for the control of contaminants from off-road sources, including utility engines.

WHEREAS, section 43018 of the Health and Safety Code directs the ARB to achieve the maximum degree of emissions reductions possible from vehicular and other mobile sources in order to accomplish the attainment of state standards at the earliest possible date;

WHEREAS, the ARB has adopted regulations under Title 13, California Code of Regulations (CCR) Section 2400, et seq. and procedures and documents to be incorporated by reference therein for 1995 and subsequent model utility and lawn and garden equipment engines, including emission standards, test procedures, emission control system warranties, enforcement procedures, and compliance testing;

WHEREAS, the staff has proposed amendments to the regulations under Title 13, CCR, Section 2400, et seq. and procedures and documents referenced therein for 1995 and subsequent model utility and lawn and garden equipment engines, including emission standards, test procedures, emission control system warranties, enforcement procedures, and compliance testing;

procedures and other requirements incorporated therein as amended at the hearing, as set forth in Attachment A;

BE IT FURTHER RESOLVED that the ARB directs the Executive Officer to adopt Title 13, CCR, sections 2400-2407 and the test procedures and other requirements incorporated therein after making substantive modifications to the text available to the public for a period of 15 days provided that the Executive Officer shall consider such written comments as may be submitted during this period, shall make modifications as may be appropriate in light of the comments received, and shall present the regulations to the ARB for further consideration if he determines that this is warranted.

BE IT FURTHER RESOLVED that the ARB hereby determines that the regulations that have been adopted to date and the amendments to the regulations approved for adoption herein will not cause the California emission standards, in the aggregate, to be less protective of public health and welfare than applicable federal standards; that California needs such standards to meet compelling and extraordinary conditions within the State; that the standards and accompanying enforcement procedures are not inconsistent with the Federal Clean Air Act, as amended.

BE IT FURTHER RESOLVED that the Executive Officer shall forward the regulations and amendments to regulations approved for adoption herein to the Administrator of EPA with a request that California be given authorization to adopt and enforce such provisions.

I hereby certify that the above is a true and correct copy of Resolution 94-50, as adopted by the Air Resources Board.

Pat Hutchens

Pat Hutchens, Board Secretary

ATTACHMENT A

CALIFORNIA REGULATIONS FOR 1995 AND LATER UTILITY AND LAWN AND GARDEN EQUIPMENT ENGINES

Adopted: March 20, 1992
Amended: April 8, 1993
Amended: _____

NOTE: This document is printed in a style to indicate changes from the existing provisions. All existing language is indicated by plain type. All additions and deletions that were proposed in Mailout 94-24 are indicated by underline and ~~strikeout~~, respectively. All additions and deletions to language contained in Mailout 94-24 are indicated by *underlined italics* and ~~*slashes*~~, respectively.

Final Regulation Order

Title 13, California Code of Regulations, Chapter 9 Off-Road Vehicles and Engines Pollution Control Devices

Article 1. Utility and Lawn and Garden Engines

2400. Applicability.

(a) (1) This article shall be applicable to utility and lawn and garden ~~equipment and~~ engines ~~used in such equipment~~ produced on or after January 1, 1995 *and any utility and lawn and garden equipment which uses engines produced on or after January 1, 1995*.

(2) Every new utility and lawn and garden equipment engine that is manufactured for sale, sold, offered for sale, introduced or delivered for introduction into commerce in, or imported into California which is subject to any of the standards prescribed in these provisions is required to be covered by an Executive Order, issued pursuant to these provisions.

(b) Each part of this article shall be deemed severable, and in the event that any part of this chapter is held to be invalid, the remainder of this article shall continue in full force and effect.

NOTE: Authority cited: Sections 39600, 39601, 43103 and 43018, Health and Safety Code.
Reference: Sections 43013, 43017 and 43018, Health and Safety Code.

2403. Exhaust Emission Standards and Test Procedures - Utility and Lawn and Garden Equipment Engines.

(a) This section shall be applicable to utility and lawn and garden equipment engines produced on or after January 1, 1995.

(b) Exhaust emissions from new utility and lawn and garden equipment engines, ~~sold in this state~~ manufactured for sale, sold, offered for sale, introduced or delivered for introduction into commerce in, or imported into California, shall not exceed:

Exhaust Emission Standards
(grams per brake horsepower-hour)

Calendar Year	Engine Class (1)	Hydrocarbon plus oxides of nitrogen (2)	Hydrocarbon (2)	Carbon monoxide	Oxides of nitrogen	Particulate
1995 to 1998	I	12.0	-	300	-	0.9 ~~(2)~~(3)
	II	10.0	-	300	-	0.9 ~~(2)~~(3)
	III (4)	-	220	600	4.0	-
	IV (4)	-	180	600	4.0	-
	V (4)	-	120	300	4.0	-
1999 and subsequent	I, II	3.2	-	100	-	0.25 ~~(3)~~(5)
	III, IV, V (4)	-	50	130	4.0	0.25 ~~(3)~~(5)

(1) "Class I" means utility and lawn and garden equipment engines less than 225 cc in displacement.
"Class II" means utility and lawn and garden equipment engines greater than or equal to 225 cc in displacement.
"Class III" means hand held utility and lawn and garden equipment engines less than 20 cc in displacement.
"Class IV" means hand held utility and lawn and garden equipment engines 20 cc to less than 50 cc in displacement.
"Class V" means hand held utility and lawn and garden equipment engines greater than or equal to 50 cc in displacement.

(2) The Executive Officer may allow gaseous-fueled (i.e., propane, natural gas) engine families, that satisfy the requirements of the regulations, to certify to either the hydrocarbon plus oxides of nitrogen or hydrocarbon emission standard, as applicable, on the basis of the non-methane hydrocarbon (NMHC) portion of the total hydrocarbon emissions.

~~(2)~~(3) Applicable to all diesel-cycle engines. ~~only~~

(d) The provisions of these specifications shall not prevent an engine manufacturer from also stating on the engine label that such engine ~~or equipment~~ conforms to any applicable federal emission standards for new equipment engines~~,~~; or any other information that ~~such~~ the engine manufacturer deems necessary for, or useful to, the proper operation and satisfactory maintenance of the ~~equipment or~~ engine.

(e) Supplemental Engine Label Content and Location.

(1) When a final equipment assembly that is marketed to any ultimate purchaser is manufactured and the engine label attached by the engine manufacturer is obscured (i.e., not readily visible), the manufacturer of the final equipment assembly (i.e., original equipment manufacturer) shall attach a supplemental engine label upon the engine or equipment. The supplemental engine label shall be of plastic or metal, and shall be welded, riveted or otherwise attached permanently to an area of the engine or equipment assembly so as to be readily visible to the average person.

(2) The manufacturer required to attach a supplemental engine label shall consider the possibility of accidental damage to the supplemental engine label in the determination of the label location. Such a label shall not be attached to any engine or equipment component that is likely to be replaced during the useful life of the engine or equipment (as applicable). Such a label shall not be attached to any engine or equipment component that is detached easily from the engine or equipment (as applicable).

(3) The written information required to be displayed upon a supplemental engine label shall be in the English language and in block letters and numerals that shall be of a color that contrasts with the background of the label.

(4) A supplemental engine label shall contain the information as specified in Subsection (c)(4), except that the date of engine manufacture specified in (c)(4)(G) may be deleted from the supplemental engine label. When the date of engine manufacture does not appear on the supplemental engine label, the responsible original equipment manufacturer shall display (e.g., label, stamp, etc.) the date elsewhere on the engine or equipment so as to be readily visible.

(f) Engine Fuel Label Content and Location.

(1) All ultimate purchasers of engines covered by these provisions shall be advised of the appropriate engine operation fuels in order that the emission characteristics of the certification test engines remain representative of production engines. This requirement shall be satisfied by a notice that indicates the appropriate fuel type (e.g., gasoline, diesel, etc.), and is located so as to be readily visible to any person who introduces fuel to the filler inlet. The engine fuel type notice shall be displayed.

(i) Upon a plastic or metal label that is attached permanently to an area of the fuel tank that is adjacent to the fuel tank filler inlet(s), or outside of any filler inlet compartment (as applicable), or.

misinterpretation, or that the location does not comply with these specifications, ~~he or she~~ the Executive Officer may require that the label or its location be modified accordingly.

~~(h)~~ *(h)* *(i)* Samples of all actual production labels used within an engine family shall be submitted to the Executive Officer within thirty days after the start of production. *Engine manufacturers shall provide samples of their own applicable production labels, and samples of applicable production original equipment manufacturer labels that are accessible to the engine manufacturers due to the direct market arrangement between such manufacturers.*

~~(i)~~ *(k)* *(j)* The Executive Officer may approve alternate label locations or may, upon request, waive or modify the label content requirements provided that the intent of these specifications is met.

~~(j) The manufacturer of any engine shall furnish to the Executive Officer, at the beginning of the calendar year, any engine identification number coding system which identifies whether such engine(s) are covered by an Executive Order.~~

~~(k)~~ *(l)* *(k)* (1) If the Executive Officer finds any engine ~~(or equipment)~~ manufacturer using labels which are different from those approved or which do not substantially comply with the readability or durability requirements set forth in these specifications, the engine manufacturer shall be subject to being enjoined from any further sales, or distribution, of such ~~products~~ noncompliant engine families, *or subgroups within the engine families*, in the State of California pursuant to Section 43017 of the Health and Safety Code. Prior to seeking to enjoin an engine manufacturer, the Executive Officer shall consider any information provided by the engine manufacturer.

(2) If the Executive Officer finds any original equipment manufacturer using labels for which it has responsibility for attaching that are different from those approved or which do not substantially comply with the readability or durability requirements set forth in these specifications, the equipment manufacturer shall be subject to being enjoined from any further sales, or distribution, of the applicable equipment product line that uses such noncompliant labels in the State of California pursuant to Section 43017 of the Health and Safety Code. Prior to seeking to enjoin an equipment manufacturer, the Executive Officer shall consider any information provided by the equipment manufacturer.

NOTE: Authority cited: Sections 39600, 39601, 43103 and 43018, Health and Safety Code.
Reference: Sections 43013, 43017 and 43018, Health and Safety Code.

2407. New Engine Compliance and Quality-Audit Testing - New Utility and Lawn and Garden Equipment Engine Selection, Evaluation, and Enforcement Action.

(a) Compliance Test Procedures.

(1) The Executive Officer may, with respect to any new engine family or subgroup being sold, offered for sale, or manufactured for sale in California, order an engine manufacturer to make available for compliance testing and/or inspection a reasonable number of engines, and may direct that the engines be delivered to the state board at the Haagen-Smit Laboratory, 9528 Telstar Avenue, El Monte, California or where specified by the Executive Officer. The Executive Officer may also, with respect to any new engine family or subgroup being sold, offered for sale, or manufactured for sale in California, have an engine manufacturer compliance test and/or inspect a reasonable number of engines at the engine manufacturer's facility under the supervision of an ARB Enforcement Officer. Engines shall be selected at random from sources specified by the Executive Officer according to a method approved by ~~him/her~~ the Executive Officer, which insofar as practical shall exclude engines which would result in an unreasonable disruption of the engine manufacturer's distribution system.

A subgroup may be selected for compliance testing only if the Executive Officer has reason to believe that the emissions characteristics of that subgroup are substantially in excess of the emissions of the engine family as a whole.

(2) For all 1995 and subsequent utility and lawn and garden equipment engines selected for compliance testing, the selection and testing of engines and the evaluation of data shall be made in accordance with the procedures set forth herein.

(3) These procedures are applicable, commencing with the 1995 calendar year, to any engine family or any subgroup within an engine family selected for compliance testing pursuant to this section.

(4) All testing shall be conducted in accordance with the applicable calendar year certification emission test procedures. Any adjustable engine parameters shall be set to values or positions that are within the range available to the ultimate purchaser (e.g., an engine carburetor with an adjustable idle fuel/air mixture shall be compliance tested at any mixture position that is within the range of adjustment available to the end-use operator). Engine service accumulation (i.e., Bbreak-in) before testing may be performed on test engines to the same extent it is performed on assembly-line quality audit testing engines (See sSubsection (b)). No break-in or modifications, adjustments, or special preparation or maintenance will be allowed on engines chosen for compliance

where:

$$U = \frac{\sum_{i=1}^{n} (x_i - \mu_o)}{\left(\sum_{i=1}^{n} (x_i - \mu_o)^2\right)^{0.5}}$$

x_i = the projected emissions of one pollutant for the ith engine tested.

μ_o = the applicable calendar year emission standard for that pollutant.

n = the number of engines tested.

(9) The Executive Officer shall find that a group of engines has failed the compliance testing pursuant to the above table if ~~he or she~~ the Executive Officer finds that the average emissions of the engines within the selected engine family or subgroup exceed the applicable calendar year new engine emission standard for at least one pollutant.

(10) If no decision for a pollutant or pollutants, can be reached after 20 engines have been tested, the Executive Officer shall not make a "Fail" decision for the selected engine family or subgroup on the basis of these 20 tests alone. Under these circumstances the Executive Officer shall elect to test 10 additional engines. If the average emissions from the 30 engines tested exceed any one of the exhaust emission standards for which a "Pass" decision has not been previously made, the Executive Officer shall render a "Fail" decision.

(11) If the Executive Officer determines, in accordance with the procedures set forth in ~~s~~Subsection (a) that an engine family, or any subgroup within an engine family, exceeds the emission standards for one or more pollutants, the Executive Officer shall:

(A) Notify the engine manufacturer that the engine manufacturer ~~shall~~ may be subject to being enjoined from any further sales, or distribution, of ~~such products~~ the noncompliant engines in the State of California pursuant to Section 43017 of the Health and Safety Code. Prior to seeking to enjoin an engine manufacturer, the Executive Officer shall consider quality audit test results, if any, and any additional test data or other information provided by the engine manufacturers and other interested parties.

production, or any subsequent calendar year production if a change is proposed, the engine manufacturer shall submit to the Executive Officer the method of quality-audit testing for approval.

(2) ~~These procedures specify the quality-audit test procedures in conjunction with the Emission Standards and Test Procedures, adopted March 20, 1992. An engine is in compliance with these quality-audit standards and test procedures only when all portions of these quality-audit test procedures and specified requirements from the Emission Standards and Test Procedures are fulfilled.~~ Standards and Test Procedures. The emission standards, exhaust sampling and analytical procedures shall be those described in the Emission Standards and Test Procedures, and which shall be applicable to engines tested only for exhaust emissions. The quality-audit test procedures are specified in conjunction with the Emission Standards and Test Procedures. An engine is in compliance with these quality-audit standards and test procedures only when all portions of these quality-audit test procedures and specified requirements from the Emission Standards and Test Procedures are fulfilled, except for the provisions as follows:

(i) A handheld equipment engine manufacturer may request that the Executive Officer allow the values of rated engine power and speed determined in the engine family certification be used in lieu of the determination of the engine power and speed of a quality-audited production engine. This request shall include a specification of the particular power absorption device (e.g., dynamometer, water brake, etc.) used to apply the test load to the production engines. An engine manufacturer shall request and must receive approval from the Executive Officer for this allowance before the quality-audit tests are conducted. The engine manufacturer should establish equivalent assurance of compliance by providing emission data from a statistically valid sample of engines for comparison between the proposed procedures and the required procedures.

(ii) Any adjustable engine parameters shall be set to any value or position that is within the range available to the ultimate purchaser.

(3) Air Resources Board (ARB) personnel and mobile laboratories shall have access to engine or equipment assembly plants, distribution facilities, and test facilities for the purpose of engine selection, testing, and observation. Scheduling of access shall be arranged with the designated engine manufacturer's representative and shall not unreasonably disturb normal operations (See sSection 31 of the Emission Standards and Test Procedures).

(4) Engine Sample Selection

(A) The engine ~~engine~~ manufacturer shall randomly select one percent of the *California sales volume of* engines from each engine family for quality-audit testing. The engines shall be representative of the engine manufacturer's California sales. All engine models within the engine family shall be included in the sample pool. Each selected engine

~~(6) Standards and Test Procedures. The emission standards and the exhaust sampling and analytical procedures shall be those described in the Emission Standards and Test Procedures, which shall be applicable to engines or equipment tested for exhaust emissions only.~~

~~(7)~~ (6) Alternate Quality-Audit Engine Selection Criteria

(A) An engine manufacturer may be allowed to use the alternate engine selection method that is outlined in this Subsection instead of the one-percent sample rate engine selection method that is required.

~~(A)~~(B) Engines or equipment shall be randomly selected at a rate of 1.0 percent of engine family production at the beginning of production. When test results of the first 10 engines or units of equipment have been accumulated, an evaluation as indicated below shall be made.

~~(B)~~(C) Calculate the family mean and standard deviation of each pollutant (HC, CO, NOx and PM) if applicable). Identify engines or units of equipment which have emission levels greater than three standard deviations above the mean. Eliminate these emission data points and recalculate the mean and standard deviation. Continue the calculation until there are no values greater than three standard deviations above the mean. Count the number of these data points greater than the emission standard (outliers). If the total number of outliers is equal to or less than the allowable number in Table 1 for each pollutant, the engine family is eligible to continue to a second evaluation, shown in paragraph (~~C~~D) below. Otherwise, sampling must continue at a rate of 1.0 percent of production for the rest of the month.

~~(C)~~(D) If the allowable outlier criterion is met, the family mean standard deviation, and sample size determined for each contaminant before excluding any outliers, are substituted in the following expression:

$$\frac{(\text{emission standard} - \text{mean})\sqrt{(N)}}{(\text{standard deviation})}$$

~~(D)~~(E) If the expression is greater than C in Table 2 below, and the engine manufacturer reasonably estimates that the quarterly engine family production will exceed 5,000 engines or units of equipment, the sampling rate for the remaining portion of the calendar month following the date of selection of the last of the 10 engines or equipment shall be 10 per month, applied on a prorated basis. If the expression is greater than C in Table 2 below, and the engine manufacturer reasonably estimates that the quarterly engine family production will be 5,000 engines or units of equipment or less, the sampling rate for the remaining portion of the

ATTACHMENT B

State of California
AIR RESOURCES BOARD

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES FOR 1995 AND LATER UTILITY AND LAWN AND GARDEN EQUIPMENT ENGINES

Adopted: March 20, 1992
Amended: April 8, 1993
Amended: _____

NOTE: This document is printed in a style to indicate changes from the existing provisions. All existing language is indicated by plain type. All additions and deletions that were proposed in Mailout 94-24 are indicated by underline and ~~strikeout~~, respectively. All additions and deletions to language contained in Mailout 94-24 are indicated by *underlined italics* and ~~*slashes*~~, respectively.

The numbering convention employed in this document, in order of priority, is: I.1.a.1.i.A.

CALIFORNIA EXHAUST EMISSION STANDARDS AND TEST PROCEDURES
FOR 1995 AND LATER
UTILITY AND LAWN AND GARDEN EQUIPMENT ENGINES

Part I. **Emission Regulations for 1995 and Later New Lawn and Garden and Utility Equipment Engines, General Provisions.**

1. General Applicability.

(a) These provisions shall be applicable to utility and lawn and garden ~~equipment~~ engines produced on or after January 1, 1995, *and any utility and lawn and garden equipment which uses engines produced on or after January 1, 1995*.

(b) Every new utility and lawn and garden equipment engine that is manufactured for sale, sold, offered for sale, introduced or delivered for introduction into commerce *in*, or imported into California which is subject to any of the standards prescribed in these provisions is required to be covered by an Executive Order issued pursuant to these provisions.

2. Definitions.

"ARB Enforcement Officer" means any officer or employee of the Air Resources Board so designated in writing by the ~~Administrator (or by his designee)~~ Executive Officer; or by the Executive Officer's designee.

"Basic Engine" means an engine manufacturer's unique combination of engine displacement, number of cylinders, fuel system, emission control system and other engine and emission control system characteristics specified by the Executive Officer.

"Executive Order" means an order issued by the Executive Officer certifying engines for sale in California.

"Class"~~,~~ see Section 9.

"Complete Engine Assembly" or "Engine Configuration" is an assembly of a basic engine and all of the specific applicable components (e.g., air inlet, fuel and exhaust systems, etc.) and calibrations (e.g., carburetor jet size, valve timing, etc.) in order that the assembly can be installed into a new unit of equipment.

"Crankcase Emissions" means airborne substances emitted into the atmosphere from any portion of the engine crankcase ventilation or lubrication system.

"Displacement", and "Displacement Class"~~,~~ see Section 16.

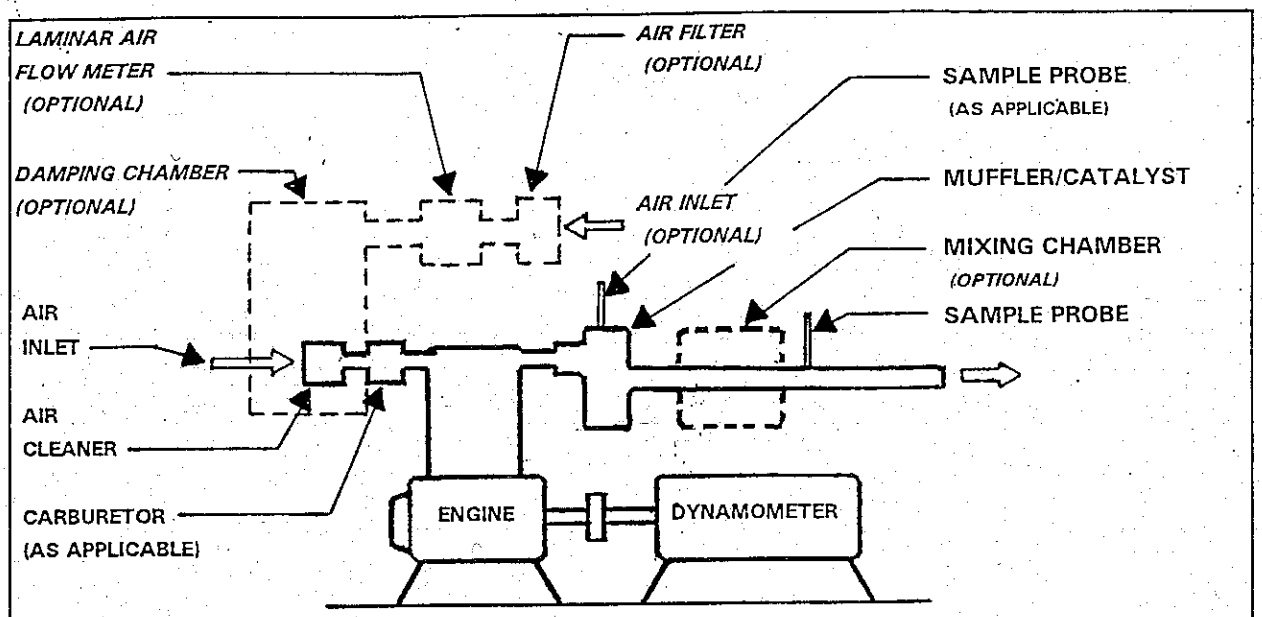

FIGURE 2-1: Engine Test Setup.

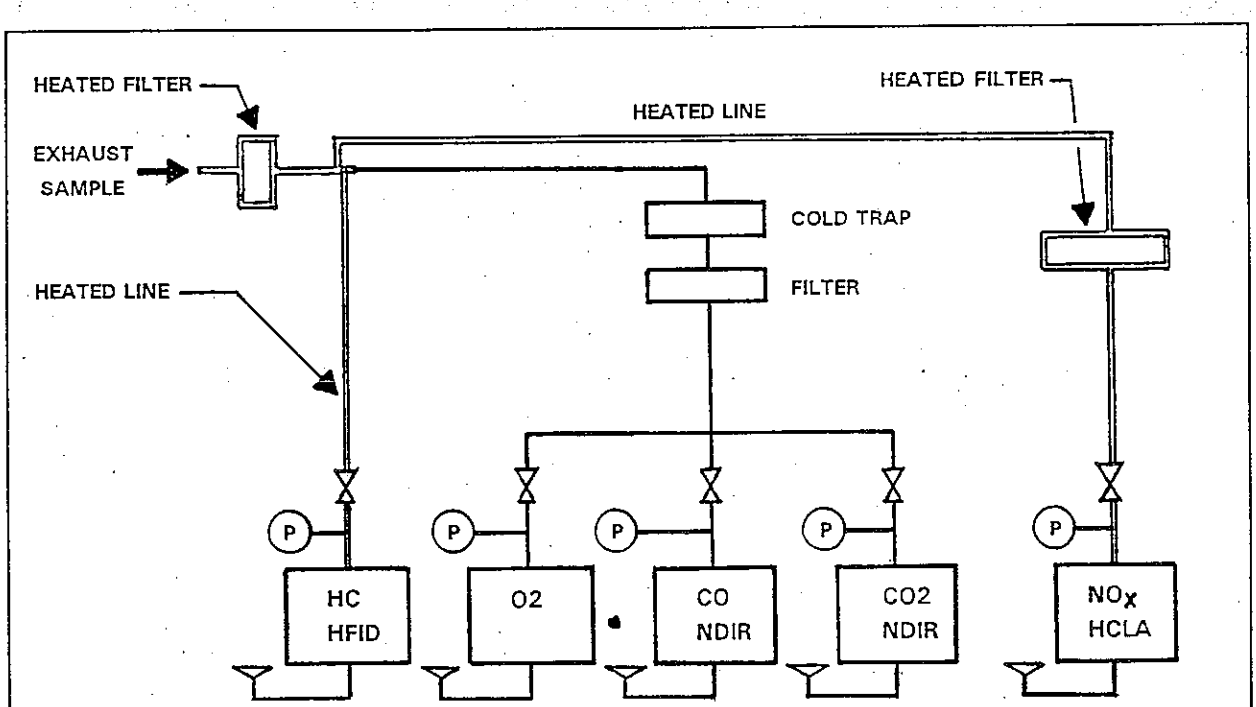

FIGURE 2-2: Exhaust Gas Analytical System with HCLA.

(i) Exhaust gases from the sample probe are separated into two or three streams depending on the sampling requirements. One sample line passes through a heated filter and leads to a heated flame ionization detector (HFID). A second sample line passes through a water trap and a filter, and leads to a nondispersive infrared analyzer (NDIR), and a chemiluminescent analyzer (CLA) or a heated CLA (HCLA). Diaphragm pumps move the filtered, dry exhaust gases to the analytical instruments. Each analyzer inlet has a valve to meter the flow rate, and gauges to measure the pressure. Flow meters located in the exhaust of each analyzer indicate the sample flow rate.

(ii) The HFID analyzer oven temperature shall be maintained between 175 to 200 ^{0}C (347 to 392 ^{0}F).

~~(e) Suggested engine setup and exhaust gas analysis systems are illustrated in Figs. 1 and 2, respectively.~~

~~(a)~~(c) Air and Fuel Measurements.

(1) Emissions measurements are made on a molar basis, and results are given in terms of concentration. ~~General practice at present is to quote~~, and emissions are reported in ~~mass~~ terms of mass (i.e., grams). Conversion of concentrations into mass may be based either on engine airflow or on fuel flow.; however, the fuel flow measurement is recommended for all engines. Conversion methods for air and fuel flow measurements are outlined in Section 14(c)(3); conversion methods for fuel flow measurements are outlined in Section 14(c)(4). ~~For two-stroke cycle engines it is recommended to use the Fuel Flow Method as described in 14(b)(2)(ii). Following paragraphs give recommended procedures for measuring air and fuel flow.~~

~~(1)~~(2) Inlet Air Flow Measurement.

(i) ~~Fig. 1 shows in schematic form the suggested inlet airflow measurement system.~~ The schematic test setup of Figure 2-1 indicates an optional inlet airflow measurement system. ~~The~~ This measurement system consists of a laminar flow meter used in conjunction with a pressure wave damping chamber. The damping chamber ~~may consist of any vessel having~~ has an internal volume not less than 100 times the displacement per cylinder of the engine under test. ~~A conventional drum of the type used for storage of petroleum products will be satisfactory for this purpose.~~ The damping chamber should be installed between the airflow metering element and the engine carburetor air inlet.; thus, serving to isolate the meter from the engine. Alternative airflow measurement systems may be substituted for the ~~preferred system prescribed above~~ shown. Such systems should adhere to the practices specified by SAE J244 (approved May 1971, ~~completely~~ revised by the Automotive Emissions Committee June 1983) which is incorporated by reference herein.

(ii) If the airflow element reduces the engine airflow and results in a ~~because of excessive~~ pressure drop that is, greater than ~~0.2~~ in H_2O ~~or 50 Pa~~ 100 Pa (0.4 in. H_2O), an auxiliary blower can be used to compensate for the effect of the air meter. If a blower is used, engine inlet pressure should be measured and controlled to +/- ~~0.2~~ in H_2O ~~(+/- 50 Pa)~~ +/- 50 Pa (+/- 0.2 in. H_2O) of barometer readings.

Figure 2-4). The holes should be sized such that each has approximately the same flow. If only three holes are used, the holes cannot be in the same radial plane.

(iii) The probe shall extend radially across the exhaust duct. The probe must pass through the approximate center and must extend across at least 80 percent of the diameter of the duct.

(iv) The probe should be located in a position that yields a well-mixed, homogenous sample of the exhaust gas.

(v) The probe should be located in the high pressure side of a muffler when the probe is located in the muffler.

~~(ii) For two-stroke cycle engines, the exhaust sample probe shall be in the high pressure side of the muffler, but as far from the exhaust port as practical. Figure 1A shows in schematic form the suggested system.~~

~~(iii)~~ (vi) ~~For~~ ~~two-stroke cycle and four-stroke engines equipped with an exhaust catalytic converter in the muffler, it shall be necessary to locate t~~The exhaust sample probe shall be located downstream from the ~~catalytic element~~ but not an exhaust catalytic converter element when the test engine is equipped with an exhaust catalytic converter. The exhaust sample probe shall not be so close to the ~~muffler~~ exhaust outlet as to ingest air from the atmosphere due to pressure pulsations in the ~~muffler~~ exhaust.

(vii) The exhaust sample probe shall be located in the exhaust conduit downstream of the exhaust valve or exhaust port of a single-cylinder engine, or downstream of the final junction of the exhaust manifold of a multi-cylinder engine*/, and shall not be so close to the exhaust outlet as to ingest air from the atmosphere due to pressure pulsations in the exhaust.*

(viii) The exhaust sample probe shall be located *in the optional location indicated in Figure 2/1 (ell/* at the exit of a mixing chamber*/* when *the optional* a mixing chamber *(optional)* is used in the test setup. The exhaust sample probe shall not be so close to the exhaust outlet as to ingest air from the atmosphere due to pressure pulsations in the exhaust.

(ix) The Executive Officer may allow an alternative location for an exhaust sample probe when the above criteria are not applicable to a particular test engine exhaust system. Such an alternative location shall be located in order to measure a well mixed, homogeneous exhaust gas sample.

~~(2)~~(3) Exhaust Mixing Chamber.

(i) The schematic test setup of Figure 2-1 indicates an optional mixing chamber component. ~~The exhaust mixing chamber is not recommended for two-stroke cycle engines. For four-stroke engines,~~ t~~The exhaust~~ mixing chamber is located in the exhaust system between the muffler and the sample probe. Its purpose is to ensure complete mixing of the engine exhaust before sample extraction so that a truly representative average exhaust sample is obtained. ~~The internal volume of the mixing chamber must be not less than 10 times the cylinder displacement of the engine under test and should be of roughly equal dimensions in height, width, and depth.~~

3. Analytical Gases.

(a) Analyzer gases.

(1) Calibration or span ~~G~~gases for the CO and CO_2 analyzers shall be ~~single blends of CO and CO_2 respectively using~~ have zero-grade nitrogen as the diluent. Combined CO and CO_2 span gases are permitted. Zero-grade nitrogen shall be the diluent for CO and CO_2 span gases.

(2) Calibration or span ~~G~~gases for the hydrocarbon analyzer shall be ~~single blends of propane using air~~ with zero-grade nitrogen as the diluent when testing gasoline-fueled engines. The diluent shall be zero-grade air when testing diesel-fueled engines.

(3) Calibration or span ~~G~~gases for NO_x analyzer shall be ~~single blends of NO~~ named as NO_x with a maximum NO_2 concentration of 5 percent of the nominal value using zero-grade nitrogen as the diluent.

(4) ~~Reserved~~ Zero-grade gases for hydrocarbon analyzers shall be nitrogen when testing gasoline-fueled engines and air when testing diesel-fueled engines. Zero-grade gases for the carbon monoxide, carbon dioxide and oxides of nitrogen analyzers shall be either zero-grade air or zero-grade nitrogen.

(5) The allowable zero-grade gas (air or nitrogen) impurity concentrations shall not exceed 1 ppm equivalent carbon response, 1 ppm carbon monoxide, 0.04 percent (400 ppm) carbon dioxide, and 0.1 ppm nitric oxide.

(6) "Zero-grade air" includes artificial "air" consisting of a blend of nitrogen and oxygen with oxygen concentrations between 18 and 21 mole percent.

(7) The use of proportioning and precision blending devices (i.e., gas dividers) to obtain the required analyzer gas concentrations is ~~allowable~~ allowed provided ~~their use has been approved in advance by the Executive Officer.~~ such devices are maintained in accordance with the instructions of the device manufacturer.

(b) Calibration gas. ~~Calibration gases shall be known to within +/-2 percent of the true values.~~

(1) Calibration gas values are to be derived from the National Institute for Standards and ~~Testing's~~ *Technology's* (NIST's) "Standard Reference Materials" (SRM's), and are to be single blends as follows:

(i) Mixtures of gases that have the following chemical compositions shall be available: C_3H_8 and zero-grade nitrogen; CO and zero-grade nitrogen; NOx and zero-grade nitrogen (the amount of NO_2 contained in this calibration must not exceed 5 percent of the NO content); and, CO_2 and zero-grade nitrogen.

(ii) The true concentration of a span gas must be within +/- 2 percent of the NIST gas standard. The true concentration of a calibration gas must be within +/- 1 percent of the NIST gas standard. All concentrations of calibration gas shall be given on a volume basis (volume percent or volume ppm).

(iii) When the gas concentration used for calibration and span is obtained by means of a gas divider the gas concentration shall be

approximately level during the emission test to prevent abnormal fuel distribution.

~~12.~~ Engine Test Procedure

~~(a)~~ Engine Preparation

~~Test the engine in the dynamometer, under mode 2 conditions, measuring fuel consumption and power before the emission measuring equipment is installed. After the emission measuring equipment is attached, the fuel flow and power should be remeasured and the results must agree within +/- 5% of the results obtained before the emission measuring equiment was attached. Particular attention must be exercised during engine mounting on the dynamometer as the fuel flow and emissions may be greatly influenced by the mounting configuration.~~

11. Engine Fuel and Lubricant Specifications.

~~(1)~~ (a) Engine Fuel Specifications.

(1) Certification Fuels.

(i) Petroleum-based fuels. The certification test fuel used for emission testing shall be consistent with the fuel specifications as outlined in the California Code of Regulations, Title 13, Section 1960.1, and the latest amendment of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles", adopted May ~~20, 1987~~ and amended July ~~12, 1991~~ and incorporated by reference herein. The test fuel specification should remain consistent from batch to batch. If a particular engine requires a ~~higher~~ different octane (or cetane) fuel, test records should indicate the fuel used.

(ii) Alcohol-based fuels. Alcohol-based fuels shall be allowed for emission test purposes when the appropriate emission standards with respect to such fuels are a part of these provisions. Such fuels shall be as specified in subparagraph (a)(1)(i) above.

(2) Service Accumulation Fuels.

(i) Gasoline.

(A) The engine manufacturer has the option to use a gasoline that satisfies the same fuel specifications as any of the certification test gasolines, or ~~U~~unleaded gasoline representative of commercial gasoline which will be generally available through retail outlets shall be used in ~~break-in procedures~~ service accumulation for petroleum gasoline-fueled ~~O~~otto-cycle ~~vehicles~~ engines. Leaded fuel shall not be used during ~~break-in procedures~~ service accumulation. ~~Additional fuel requirements for break-in procedures are as follows:~~

~~(i) Engine lubricants representative of commercially available engine lubricants which will be generally available through retail outlets shall be used by manufacturers.~~

~~(ii)~~ (B) The octane rating of the gasoline used shall be no higher than 4.0 Research ~~o~~Octane ~~n~~Numbers above the minimum recommended by the engine manufacturer when a certification fuel is not used for service

(b) Engine Dynamometer Test Run.

(1) Engine and Dynamometer Start-up.

(i) Only engine adjustments in accordance with Section 22 of Part I shall be allowed prior to the start of a test.

(ii) The dynamometer shall be warmed up as necessary, and as recommended by the dynamometer manufacturer; or use good engineering practice.

(iii) An engine may be operated using the engine's speed governor if the engine is so equipped, or with the throttle in a fixed position. The requirements of paragraph (d) of this Section must be satisfied.

(2) The following steps shall be conducted for each test:

(i) Record applicable data as specified in Section 13.

(ii) Spark-ignition engines ~~shall~~ *are recommended to* be preconditioned by operating the engine at a power greater than or equal to 50 percent maximum power at the rated or intermediate speed (as applicable) for 20 minutes.

(iii) Diesel-cycle engines shall be preconditioned as follows:

(A) Operate the engine at idle for 2 to 3 minutes;

(B) Operate the engine at approximately 50 percent power at the maximum torque speed for 5 to 7 minutes; and,

(C) Operate the engine at rated speed and maximum power for 25 to 30 minutes.

(iv) For both spark-ignition and diesel-cycle engines, the engine service accumulation may be substituted for the engine preconditioning if such service accumulation has been occurring for at least 40 minutes prior to commencing the test cycle.

(v) The test cycle portion of the emission test (i.e., the initial thermal stabilization determination) shall begin within 5 minutes after completing the engine preconditioning.

(vi) Test modes shall be performed in the numerical order specified for the appropriate test cycle.

(vii) Determine the maximum engine torque output at the rated or intermediate engine speed, as applicable. For non-handheld engines, determine and record the torque values that correspond to 75, 50, 25 and 10 percent of the maximum engine torque output. The minimum torque capability of an engine may be substituted for the 10-percent value when a 10-percent value of the maximum engine torque output is not attainable.

(viii) Once engine speed and load are set for a particular mode, the engine shall be operated for a sufficient period of time to achieve thermal stability. The objective is to stabilize all engine parameters that affect emissions prior to the start of any emissions measurements. The method used to determine thermal stability (e.g., variation in cylinder temperature, engine oil temperature, etc.) shall be recorded.

(ix) Record continuously all modal emission data specified in Section 13 (as applicable) for a minimum of two (2) minutes and as dictated by good engineering practice in order to obtain accurate and

Note: Where there is no rated speed given, the speed at maximum horsepower should be used. Max governed speed is the manufacturers recommended maximum speed obtained while using a throttling governor. Terminal speed is the maximum attainable speed without any load applied to the enigne. Beam load is the load measured by the dynamometer. Full load is the maximum load which can be applied at a given condition.

(c) Exhaust Gas Measurements.

(1) Measure HC, CO, CO_2 and NOx concentrations in the exhaust sample.

(2) Each analyzer range that may be used during a test cycle shall have the zero and span response recorded prior to the execution of each test cycle. Only the range(s) used to measure the emissions during a test cycle is required to have its zero and span recorded after the completion of the test cycle. The span shall be conducted at the same flow rates used to analyze the test sample. Span gases should have concentrations of 75 to 100 percent of full scale. Actual concentrations shall be recorded.

(3) Filter elements may be replaced between modes.

(4) System leak checks may be performed between modes.

(5) A hydrocarbon hang-up check may be performed between modes.

(d) Engine Test Cycle.

(1) The appropriate six-mode test cycle for non-handheld equipment engines, and the appropriate two-mode test cycle for handheld equipment engines, shall be utilized (See Table 1-1 Engine Test Cycles; Part I, Section 20).

(2) The engine speed and load values specified in Table 1-1 Engine Test Cycles, Section 20, Part I, shall be maintained to within +/- five (5) percent for a power mode. The engine speed only shall be maintained to within +/- ten (10) percent of the engine manufacturer's specified engine idle speed for an idle mode. *The engine load values specified in Table 1-1 Engine Test Cycles, Section 20, Part I, shall be maintained, for all applicable loads, to within the larger range provided by +/- 0.27 Nm (+/- 0.2 lb-ft), or +/- ten (10) percent of the specified load value for loads of 50 percent and less, or +/- five (5) percent of the specified load value for loads above 50 percent. When a torque that is less than 0.27 Nm (0.2 lb/ft) is applied to the engine, the engine speed and load shall be maintained to the smallest tolerance that is possible within the capilities of the test equipment and by the use of good engineering practice. Such All* tolerance ranges shall be determined and recorded for each test mode.

(3) The Executive Officer shall specify tolerances for engine speed and load for test purposes when such specifications are supported by test data and results, surveillance information, and other engineering information.

(e) Analyzer Post-Test Procedures.

(1) *Perform Begin* a hydrocarbon hang-up check within one minute of the completion of the last mode in the test cycle.

(6) Fuel mass flow rate for each mode.

(7) Engine inlet air flow for each mode (as applicable).

(8) Pollutant mass flow.

(9) Exhaust mixing chamber surface temperature (as applicable).

(10) Exhaust sample line temperatures (as applicable).

(11) Ambient test environmental conditions (e.g., temperature, barometric pressure, saturation vapor pressure, absolute humidity, etc.). A central laboratory barometer may be used for pressure measurements; however, individual test cell barometric pressures must be within +/- 0.1 percent of the barometric pressure at the central barometer location.

~~(f)~~(g) Dynamometer Information: Manufacturer, model, serial number~~:~~. As an alternative to recording ~~the dynamometer serial number~~ this information, a reference to a engine test cell number may be used, with the advance approval of the Executive Officer, provided the test cell records show the pertinent instrument information.

~~(g)~~(h) All pertinent instrument information such as tuning-, gain-, serial numbers-, detector numbers,-~~range~~ and calibration curves. As an alternative, a reference to a engine test cell number may be used, with the advance approval of the Executive Officer, provided test cell calibration records show the pertinent instrument information.

~~(h)~~(i) Recorder Charts or other data acquisition devices: ~~Identify zero, span, exhaust gas, and dilution air sample, traces.~~

(1) Record and identify for each test cycle the zero traces and span traces for each range used.

(2) Record and identify for each test mode the emission concentration traces and the associated analyzer ranges(s).

(3) Record and identify the hang-up check.

~~(i) Test cell barometric pressure, ambient temperature and humidity.~~

~~Note: A central laboratory barometer mat be used; Provided, that individual test cell barometric pressures are shown to be within +/- 0.1 percent of the barometric pressure at the central barometric location.~~

14. Data Reduction and Presentation of Results.

(a) Engine Performance. The mass emission calculations presented in this Section are specific to gasoline fuels only. Mass emission calculations for *Phase II reformulated gasoline, or other* alternatively fueled engines should use a different set of constants (i.e., utilization of the molecular weight of the test fuel). The ~~following~~ engine operating and performance parameters *(as applicable)* listed in Table 2-1 Engine Test Parameters ~~should~~ shall be presented for each test in the SI units (English units shall be indicated~~:~~ in parentheses).

APPENDIX A

(a) When FID (flame ionization detector) is used in HC analysis and a chemiluminescent analyzer utilizing a wet sample is used for NO analysis, the combustion water is not removed and therefore measurements are made with reference to the wet exhaust. When NDIR and chemiluminescent analyzer requiring a dry sample are used for species analysis, water vapor is removed prior to the concentration measurement and the results are on a dry basis. The following equation may be used to determine the correction factor to be used in converting dry measurements to a wet basis.

$$K = \frac{1}{1+0.005 \times (CO\% + CO_2\%) \times y - (0.01 \times H_2)}$$

where:

$$H_2 = \frac{0.5 \times y \times CO\% \times (CO\% + CO_2\%)}{(CO\% + (3.5 \times CO_2\%))}$$

y= H/C ratio of test fuel

Therefore: Species concentration, wet= K x species concentration, dry

For two-stroke cycle engines, we assume no residual free H_2 and modify K by deleting the H_2 term.

(b) The above method does not include a correction for air humidity. The humidity contribution to the exhaust is small and may be neglected. If it is desired to include the effects of humidity, Appendix C gives the derivation of a general equation which may be used to determine the correction factor.

analyzers may be used if shown to yield equivalent results and if approved in advance by the Executive Officer.

(2) The carbon monoxide (CO) NDIR analyzer may require a sample conditioning column containing $CaSO_4$, or indicating silica gel to remove water vapor and containing ascarite to remove carbon dioxide from the CO analysis stream.

(i) If CO instruments which are essentially free of CO_2 and water vapor interference are used, the use of the conditioning column may be deleted, see Sections 11 and 26.

(ii) 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 percent CO_2 in N_2 which has been bubbled through water at room temperature produces an equivalent CO response, as measured on the most sensitive CO range, which is less than 1 percent of full scale CO concentration on ranges above 300 ppm full scale or less than 3 ppm on ranges below 300 ppm full scale; see Section 11.

(c) Other analyzers and equipment. Other types of analyzers and equipment may be used if shown to yield equivalent results and if approved in advance by the Executive Officer.

4. Engine Fuel and Lubricant Specifications. ~~Fuel and engine lubricant specifications.~~

(a) Engine Fuel Specifications.

(1) Certification Fuels.

(i) Petroleum-based fuels. The certification test fuel used for emission testing shall be consistent with the fuel specifications as outlined in the California Code of Regulations, Title 13, Section 1960.1, and the latest amendment of the "California Exhaust Emission Standards and Test Procedures for 1988 and Subsequent Model Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles", adopted ~~May 20, 1987~~ and amended ~~July 12, 1991~~ and incorporated by reference herein. The test fuel specification should remain consistent from batch to batch. If a particular engine requires a ~~higher~~ different octane (or cetane) fuel, test records should indicate the fuel used.

(ii) Alcohol-based fuels. Alcohol-based fuels shall be allowed for emission test purposes when the appropriate emission standards with respect to such fuels are a part of these provisions. Such fuels shall be as specified in subparagraph (a)(1)(i) above.

(2) Service Accumulation Fuels.

(i) Gasoline.

~~(A)(b)~~ The engine manufacturer has the option to use a gasoline that satisfies the same fuel specifications as any of the certification test gasolines, or ~~U~~unleaded gasoline representative of commercial gasoline which will be generally available through retail outlets shall be used in ~~break-in procedures~~ service accumulation for ~~petroleum~~ gasoline-fueled ~~O~~otto-cycle ~~vehicles~~ engines. Leaded fuel shall not be used during ~~break-in procedures~~ service accumulation. ~~Additional fuel requirements for break-in procedures are as follows:~~

(6) "Zero-grade air" includes artificial "air" consisting of a blend of nitrogen and oxygen with oxygen concentrations between 18 and 21 mole percent.

(7) The use of proportioning and precision blending devices (i.e., gas dividers) to obtain the required analyzer gas concentrations is allowedable provided their use has been approved in advance by the Executive Officer. such devices are maintained in accordance with the instructions of the device manufacturer.

(b) Calibration gas. Calibration gases shall be known to within +/-2 percent of the true values.

(1) Calibration gas values are to be derived from the National Institute for Standards and *Testing's Technology's* (NIST's) "Standard Reference Materials" (SRM's), and are to be single blends as follows:

(i) Mixtures of gases that have the following chemical compositions shall be available: C_3H_8 and zero-grade air; CO and zero-garde nitrogen; NOx and zero-grade nitrogen (the amount of NO_2 contained in this calibration must not exceed 5 percent of the NO content); and, CO_2 and zero-grade nitrogen.

(ii) The true concentration of a span gas must be within +/- 2 percent of the NIST gas standard. The true concentration of a calibration gas must be within +/- 1 percent of the NIST gas standard. All concentrations of calibration gas shall be given on a volume basis (volume percent or volume ppm).

(iii) When the gas concentration used for calibration and span is obtained by means of a gas divider the gas concentration shall be diluted with either zero-grade N_2 or zero-grade air (as applicable). The accuracy of the diluted gases may be determined to within +/- 2 percent.

(iv) Fuel for the FID detector shall be a blend of 40 +/- 2 percent hydrogen with the balance as helium. The mixture must contain less than 1 ppm equivalent carbon response; 98 to 100 percent hydrogen fuel may be used with advance approval of the Executive Officer.
he accuracy of the diluted gases may be determined to within +/- 2 percent.

(v) Oxygen interference check gases must contain propane with 350 +/- 75 ppmC hydrocarbon. The concentration value to calibration gas tolerances shall be determined by chromatographic analysis of total hydrocarbons plus impurities, or by dynamic blending. Nitrogen must be the predominant diluent with the balance oxygen.

(vi) Hydrocarbon analyzer burner air. The concentration of oxygen must be within 1 mole percent of the oxygen concentration of the burner air used in the latest oxygen interference check (percent O_2I). If the difference in oxygen concentration is greater than 1 mole percent, the oxygen interference must be checked and the analyzer adjusted (as necessary) to satisfy the percent O_2I requirements. The burner air must contain less than 2 ppmC hydrocarbon.

6. [Reserved]. Exhaust Emission Measuring Procedure.

(a) The steady-state test modes used for measuring exhaust emissions are listed in Section II(4).

(3) Analyzer zero and span shall be checked before and after each test cycle.

(4) System flow rates and pressures shall be checked, and re-set as required.

18. Engine Preconditioning.

~~(a) The engine shall be moved to the test area and the following operations performed:~~

~~(1) The fuel tank(s) shall be drained and charged with the specified test fuel, Section 4, to half the tank(s) capacity.~~

~~(2) The engine shall be placed on a dynamometer and operated through the applicable mode schedule (see Section II (12)). The engine need not be cold, and may be used to set dynamometer horsepower.~~

~~(b) Within five (5) minutes of completion of preconditioning, the engine shall be removed from the dynamometer and moved to the soak area. The engine shall be stored for not less than the following times prior to the cold start exhaust test.~~

~~In no case shall the engine be stored for more than 36 hours prior to the exhaust test.~~

(a) Spark-ignition engines ~~shall~~ *are recommended to* be preconditioned as follows:

(1) Operate the engine at a power greater than or equal to 50 percent maximum power at the rated or intermediate speed (as applicable) for 20 minutes.

(b) Diesel-cycle engines shall be preconditioned as follows:

(1) Operate the engine at idle for 2 to 3 minutes;

(2) Operate the engine at approximately 50 percent power at the maximum torque speed for 5 to 7 minutes; and,

(3) Operate the engine at rated speed and maximum power for 25 to 30 minutes.

(c) For both spark-ignition and diesel-cycle engines, the engine service accumulation may be substituted for the engine preconditioning if such service accumulation has been occurring for at least 40 minutes prior to commencing the test cycle.

(d) The test cycle portion of the emission test (i.e., the initial thermal stabilization determination) shall begin within 5 minutes after completing the engine preconditioning.

(e) Test modes shall be performed in the numerical order specified for the appropriate test cycle.

(f) Determine the maximum engine torque output at the rated or intermediate engine speed, as applicable. For non-handheld engines, determine and record the torque values that correspond to 75, 50, 25 and 10 percent of the maximum engine torque output. The minimum torque capability of an engine may be substituted for the 10-percent value when a 10-percent value of the maximum engine torque output is not attainable.

(e) If the dynamometer horsepower must be adjusted manually, it shall be set within one hour prior to the exhaust emissions test phase. The test engine shall not be used to make this adjustment. Dynamometers using automatic control of preselectable power settings may be set anytime prior to the beginning of the emissions test.

20. Engine Starting and Restarting.

(a) (1) The engine shall be started according to the manufacturer's recommended starting procedures.

(2) Choke operation. (i) Engines equipped with automatic chokes shall be operated according to the instructions in the engine manufacturer's operating instructions or owner's manual, including choke setting and "kick down" from cold fast idle.

(ii) Engines equipped with manual chokes shall be operated according to the engine manufacturer's operating instructions or owner's manual. When times are provided in the instructions, the Executive Officer may specify the specific point for operation, within 15 seconds of the recommended time.

(3) The operator may use the choke, throttle etc. where necessary to keep the engine running.

(4) If the manufacturer's operating instructions or owner's manual do not specify a warm engine starting procedure, the engine (automatic and manual choke engines) shall be started by opening the throttle about half way and cranking the engine until it starts.

(b) Reserved.

(c) If the engine does not start after ten seconds of cranking, or ten cycles of the manual starting mechanism, cranking shall cease, the test shall be voided, the engine removed from the dynamometer, corrective action taken in accordance with Sections I (22 and 23), and the engine rescheduled for test. The reason for the malfunction (if determined) and the corrective action taken shall be reported.

(d) If the engine "false starts", the operator shall repeat the recommended starting procedure (such as resetting the choke, etc.)

(e) Stalling. (1) If the engine stalls during an operating mode, the engine shall be restarted immediately and the test continued.

(2) If the engine will not restart within one minute, the test shall be voided, the engine removed from the dynamometer, corrective action taken, and the engine rescheduled for test. The reason for the malfunction (if determined) and the corrective action taken shall be reported.

21. Dynamometer Test Runs.

(a) The engine shall be allowed to stand with the engine turned off (see Section 18 for required time). The engine shall be stored prior to the emission test in such a manner that precipitation (e.g., rain or dew) does

eighty-five (85) percent of full-scale deflection, and be equipped with automatic range change circuitry, and other requirements that may be specified by the Executive Officer.

(c) Gather samples of all required modal emission data specified in Section 25. The duration of time during which these data are recorded shall be labeled as the "sampling period". The data collected during the sampling period shall be used for modal emission calculations.

(e) A test mode may be repeated.

(f) If a delay of more than one (1) hour occurs between the end of one mode and the beginning of another mode, the test is void and shall be re-started with the engine preconditioning sequence (Section 18).

(g) The engine speed and load values specified in Table 1-1 Engine Test Cycles, Section 20, Part I, shall be maintained to within +/- five (5) percent for a power mode. The engine speed only shall be maintained to within +/- ten (10) percent of the engine manufacturer's specified engine idle speed for an idle mode. *The engine load values specified in Table 1-1 Engine Test Cycles, Section 20, Part I, shall be maintained, for all applicable loads, to within the larger range provided by +/- 0.27 Nm (+/- 0.2 lb-ft), or +/- ten (10) percent of the specified load value for loads of 50 percent and less, or +/- five (5) percent of the specified load value for loads above 50 percent. Where a torque that is less than 0.27 Nm (0.2 lb/ft) is applied to the engine, the engine speed and load shall be maintained to the smallest tolerance that is possible within the capabilities of the test equipment and by the use of good engineering practice. Such* All tolerance ranges shall be determined and recorded for each test mode.

(h) The Executive Officer shall specify tolerances for engine speed and load for test purposes when such specifications are supported by test data and results, surveillance information, and other engineering information.

(i) If the test equipment malfunctions at any time during a test mode, the test is void and shall be aborted. Corrective action should be taken and the test re-started.

(j) If the engine stalls while in a test mode, the engine shall be re-started immediately and the test continued at Section 18(d) of this Part. If the engine is not re-started within two (2) minutes, the test shall be voided. If maintenance is required on the engine, advanced approval from the Executive Officer is required as specified in Section 23 of Part I. After corrective action is taken, a test of the engine may be re-scheduled. The reason for the malfunction (if determined) and the corrective action conducted.

(10) [Reserved].

(11) Exhaust sample line temperatures (as applicable).

(12) Ambient test environmental conditions (e.g., temperature, barometric pressure, saturation vapor pressure, absolute humidity, etc.). A central laboratory barometer may be used for pressure measurements; however, individual test cell barometric pressures must be within +/- 0.1 percent of the barometric pressure at the central barometer location.

~~(f)~~(g) Dynamometer Information: Manufacturer, model, serial number~~:~~. As an alternative to recording ~~the dynamometer serial number~~ this information, a reference to a engine test cell number may be used, with the advance approval of the Executive Officer, provided the test cell records show the pertinent instrument information.

~~(g)~~(h) All pertinent instrument information such as tuning-, gain-, serial numbers-, detector numbers,-range and calibration curves. As an alternative, a reference to a engine test cell number may be used, with the advance approval of the Executive Officer, provided test cell calibration records show the pertinent instrument information.

~~(h)~~(i) Recorder Charts or other data acquisition devices: ~~Identify zero, span, exhaust gas, and dilution air sample, traces.~~

(1) Record and identify for each test cycle the zero traces for each range used, and span traces for each range used.

(2) Record and identify for each test mode the emission concentration traces and the associated analyzer ranges(s).

(3) Record and identify the hang-up check.

~~(i) Test cell barometric pressure, ambient temperature and humidity.~~

~~Note: A central laboratory barometer may be used, Provided, that individual test cell barometric pressures are shown to be within +/- 0.1 percent of the barometric pressure at the central barometric location.~~

26. Calculations: Exhaust Emissions.

The final reported test results, ~~with oxides of nitrogen being optional,~~ shall be computed by use of the following formula: (The results of all emission tests shall be rounded, using the "Rounding-Off Method" specified in ASTM E 29-90, to the number of places to the right of the decimal point indicated by expressing the applicable standard to three significant figures.)

(a) Specific Emissions.

(1) The weighted emission rates for each individual gas component shall be calculated as follows:

$$\text{Emission Rate} = \frac{\Sigma\,(\text{Gas Mass}_i) \times (WF_i)}{\Sigma\,(\text{Power}_i) \times (WF_i)}$$

(iv) (A) HC_e = Hydrocarbon concentrations of the dilute exhaust sample as measured, in ppm carbon equivalent (propane ppm X 3).

(B) HC_d = Hydrocarbon concentration of the dilution air exhaust sample as measured, in ppm carbon equivalent (propane ppm x 3).

(2) (i) NOx_{mass} = Oxides of nitrogen emissions, grams per test phase.

(ii) $Density_{NO2}$ = Density of oxides of nitrogen in the exhaust gas, assuming they are in the form of nitrogen dioxide, 1913 g/m^3 (54.16 g/ft^3), at 20 ^oC (68 ^oF) and 101.3 kPa (760 mm Hg) pressure.

(iii) (A) NOx_{conc} = Oxides of nitrogen concentration of the dilute exhaust sample corrected for background, ppm.

(B) $NOx_{conc} = NOx_e - NOx_d(1 - (1/DF))$

Where:

(iv) NOx_e = Oxides of nitrogen concentration of the dilute exhaust sample as measured, ppm.

(v) NOx_d = Oxides of nitrogen concentration of the dilution air as measured, ppm.

(3)(i) CO_{mass} = Carbon monoxide emissions, in grams per test phase.

(ii) $Density_{CO}$ = Density of carbon monoxide, 1164 g/m^3(32.97g/ft^3), at 20 ^oC (68 ^oF) and 101.3 kPa (760 mm Hg) pressure.

(iii) (A) CO_{conc} = Carbon monoxide concentration of the dilute exhaust sample correct for background, water vapor, and CO_2 extraction, ppm.

(B) $CO_{conc}=CO_e - CO_d(1 - (1/DF))$

Where:

(iv) (A) CO_e = Carbon monoxide concentration of the dilute exhaust sample volume corrected for water vapor and carbon dioxide extraction, in ppm. The calculation assumes the carbon to hydrogen ratio of the fuel is 1:1:85.

(B) $CO_e = (1 - 0.01925CO_{2e} - 0.000323R)CO_{em}$

Where:

(ii) V_o = Volume of gas pumped by the positive displacement pump, in cubic meters per revolution. This volume is dependent on the pressure differential across the positive displacement pump. (See calibration techniques in Section 9).

(iii) N = Number of revolutions of the positive displacement pump during the test phase while samples are being collected.

(iv) P_B = Barometric pressure, kPa.

(v) Pi = Pressure depression below atmospheric measured at the inlet to the positive displacement pump, kPa.

(vi) T_p = Average temperature of dilute exhaust entering positive displacement pump during test while samples are being collected, °K.

(vii) (A) K_h = Humidity correction factor.

(B) $K_h = 1/[1 - 0.0329(H - 10.71)]$ *(Gasoline)*

$K_h = 1/[1 - 0.0182(H - 10.71)]$ (Diesel)

Where:

(viii)(A) H = Absolute humidity in grams of water per kilogram of dry air.

(B) $H = [(6.211)R_a \times P_d]/[P_B - (P_d \times R_a / 100)]$

(ix) R_a = Relative humidity of the ambient air, pct.

(x) P_D = Saturated vapor pressure, in kPa at the ambient dry bulb temperature.

(xi) P_B = Barometric pressure, kPa.

27. [Reserved]. ~~Calculations; Particulate Exhaust Emissions.~~

~~(a) The final reported steady-state emission test results shall be computed by use of the following formula:~~

$$P_{wm} = \frac{P_H}{BHP\text{-}hr}$$

~~(1) P_{wm} = Weighted mass particulate, grams per brake horsepower-hour.~~

~~(2) P_H = Mass particulate measured during the hot running exhaust test, grams.~~