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TO: ALL MANUFACTURERS OF SMALL UTILITY ENGINES
ALL MANUFACTURERS OF LAWN AND GARDEN EQUIPMENT
ALL MANUFACTURERS OF CHAIN SAWS
ALL OTHER INTERESTED PARTIES

SUBJECT: SMALL-ENGINE CERTIFICATION PROCEDURES

On December 14, 1990, the Air Resources Board approved regulations regarding exhaust emission standards and test procedures for 1994 and later utility and lawn and garden equipment engines (small engines). This letter transmits a Manufacturers Advisory Correspondence which suggests procedures for selecting test engines for certification emission test purposes, and considerations for providing the tamper resistance assurance of engines with adjustable parameters.

If there are questions or comments, please contact Mr. Duc Nguyen, Manager, or Mr. Ronald Haste, Staff Engineer, Certification Section at (818) 575-7067.

Sincerely,

K. D. Drachand, Chief
Mobile Source Division

Enclosure

State of California
AIR RESOURCES BOARD

MANUFACTURERS ADVISORY CORRESPONDENCE 92-06

Subject: This Manufacturers Advisory Correspondence (MAC) suggests (1) the engine selection criteria for certification emission testing, and (2) tamper resistant measures that should be considered for engines with adjustable parameters.

Applicability: All engine manufacturers of small engines subject to the California exhaust emission standards and test procedures for 1994 and later utility and lawn and garden equipment engines, and manufacturers of equipment offered for sale in California beginning in 1994 which use California-certified small engines.

References:

1. Mail-Out #91-46, "Guidelines For Certification of 1994 & Later Lawn & Garden and Small Utility Engines", September 20, 1991.

2. "California Exhaust Emission Standards and Test Procedures for 1994 and Later Utility and Lawn and Garden Equipment Engines", adopted March 20, 1992.

[References to these are indicated by brackets]

Definitions: "Small engine" is a two- or four-stroke, air- or liquid-cooled internal combustion engine with a rated output below 25 horsepower fueled by gasoline, diesel or some other alternative fuel.

"Engine Family" means the basic classification unit of a manufacturer's engine product line used for the purpose of certification and test-engine selection.

"Basic Engine" means a unique combination of engine displacement, number of cylinders, fuel system, catalyst usage.

"Engine-System Combination" means an engine family-displacement-emission control system combination. An engine-system combination is a subclassification of an engine family on the basis of the basic engine, the displacement and the emission control system. An engine-system combination means an "Engine-Displacement-System Combination" [Reference 2, Part I, Section 2].

"Engine Configuration" means a subclassification of an engine-system combination on the basis of the engine calibration, and the subsystem components, such as the muffler, the air cleaner, the carburetor.

"Special Tools" are tools or fixtures which are specified by an engine manufacturer and are intended to perform only a specific function. The effective usage of these tools requires special training or expertise.

TEST ENGINE SELECTION

Background: As part of small-engine certification, engine manufacturers are required to provide in the application the emission test data for each test engine [Reference 2, Part I, Sections 25(a) and 27(a)(1)]. The test procedures require the ARB to select test engines so that each engine family-displacement-emission control system combination (engine-system combination) is represented. Further, the ARB shall select the engine configuration within the engine-system combination which has the greatest probability of exceeding the standards [Reference 2, Part I, Section 18(a)]. The ARB will consider an engine manufacturer's recommendations for the test engine selection. Engine manufacturers should include their recommended test engine selections, for ARB review and approval, in the initial submission of the certification application.

Discussion: Selection Criteria

The engines within an engine family are expected to have similar emission characteristics. An evaluation of an engine's emission characteristics will consider the basic engine design (such as, displacement, number of cylinders, engine bore and stroke), subsystems of the engine system (such as, the fuel system, the cooling mechanism, the method of air aspiration, etc), and individual components or subsystems (such as, thermal reactor characteristics or catalyst characteristics) [See Engine Families, Reference 2, Part I, Section 17]. The engine family may be refined further according to the factors outlined in the Engine Family Determination [Reference 1, Attachment C]. These factors involve further consideration and a more detailed scrutiny of the basic engine design (such as, the cylinder bore center-to-center dimension), engine subsystems (such as, the fuel system), subsystem components (such as, catalytic converters), and specific criteria (such as, a displacement allowance of up to fifteen percent of the largest engine displacement in the family). The goal of an engine family determination is to combine engines into groups which have the least variation with respect to the aforementioned factors. It is expected that engines with such similar factors will exhibit similar emission characteristics.

A subclass of an engine family is an engine-system combination. Each engine-system combination is unique in that each of its engines has the same basic engine, displacement and emission control system. There may be one or several engine-system combinations within an engine family. For example, an engine family is comprised of two sets of engines that are identical in all aspects, except that one set may have a displacement that is smaller than the displacement of the other set. In such a case, there would be two engine-system combinations within the one engine family and they would be characterized by the different displacements.

A subclass of an engine-system combination is an engine configuration. Each engine configuration is unique because of the particular subsystem components (such as, mufflers or fuel tanks) that comprise the final-assembly engine. While engines within an engine-system combination use similar subsystem components, they may not use components that are exactly the same. The design objective of the engine with respect to its end-use application may require the use of one particular model of a subsystem component, while another engine may require the use of a different model of the same component. For example, engines within an engine-system combination are anticipated to have similar exhaust systems, but each may use different models of mufflers. Thus, a separate engine configuration would be formed for each model of muffler that was used on the engine-system combination.

While engines within an engine family are expected to exhibit similar emission characteristics, the emission levels of a particular engine configuration may not be the same as the other configurations in the family. The efficiency with which an engine produces power is dependent on its configuration - the form, fit and function of its basic engine, subsystems and subsystem components. Due to the uniqueness of its configuration, a particular engine configuration is likely to have a lower power production efficiency than other configurations in the engine family and this will impact its emission results. Since the emission standards are specific with respect to the power output of the engine, an engine with a lower power output will produce higher specific emission values. As such, the engine configuration with the lowest power production efficiency would have the highest probability of exceeding the standards, and it should be a candidate engine for emission testing.

The criteria suggested in the following policy section reflect the power output specific nature of the standards by selecting factors which affect directly the power production of the engine. The objective of the selection method is to rate the power production efficiency of an engine configuration. This determination of efficiency may be accomplished through different approaches. Factors that are not included in the following policy section may merit consideration as selection criteria. For example, an engine efficiency could possibly be defined using a ratio of power output to fuel consumption (brake-specific fuel consumption). Future testing and experience may reveal a more precise and definite selection criteria.

Some factors are not acceptable for use as selection criteria. For example, the end-use application of an engine should not be considered in selecting a test engine because the weighted mode format of the test procedure has already taken into account the variability of the end-use applications [Reference 2, Part II, Section 12(b) and Part III, Section 6]. For similar reasons, estimated sales figures should not be considered.

Incomplete Engine Subassemblies

Some engine manufacturers market to original equipment manufacturers (OEMs) incomplete engine subassemblies which lack certain engine subsystem components (such as, air cleaners, exhaust manifolds, or mufflers). In such instances, separate engine-component suppliers market to OEMs the necessary subsystem component required to complete the final assembly of the engine. The addition of particular subsystem component models completes and defines the engine configuration. Since an engine family may be marketed to numerous OEMs and these OEMs may install numerous varieties of the subsystem component models for final assembly purposes, the potential number of ultimate engine configurations may be significant.

Whether or not engines within an engine family are marketed as completed engine assemblies or as incomplete engine subassemblies, engine manufacturers are required to demonstrate engine family compliance with the emission standards by completing the certification process (See Policy 1 and 2). They are further required to demonstrate compliance with the standards through quality-audit and compliance testing of an engine family. The ARB does not require component manufacturers or OEMs to certify or quality-audit and compliance test their products. Accordingly, the ARB encourages engine manufacturers to communicate the pertinent engine specifications (such as, inlet and exhaust requirements, duty cycles, critical engine temperatures, etc.) to the appropriate component manufacturers or OEMs so that these manufacturers are aware of the engine manufacturer's expectations regarding engine emissions. At the same time, component manufacturers and OEMs are encouraged to recognize the benefits of following the engine manufacturer's specifications when producing components or completing the final assembly. Since it is the engine manufacturers who bear the burden of providing engine certification and demonstrating compliance to the ARB, it is imperative that the engine manufacturers and the engine component manufacturers and OEMs coordinate their requirements so that the emission certification of the final assembly engine configuration is not impaired [Reference 2, Part 1, Section 18(a), also see Section 17].

<u>Policy</u>: 1. <u>Test Engine Selection</u>

To assist engine manufacturers in selecting the appropriate engine configuration for testing purposes, engine manufacturers should consider the following criteria which are presented in descending order of priority [Reference 2, Part 1, Section 18(a), also see Part 1, Section 17(b)]. In recognition that power output is not always the prime consideration in an engine design, the ARB will allow engine manufacturers to propose other selection criteria or a different order of priority. The proposal should include supporting documentation and test results.

A. Bore-to-Stroke Ratio

Engines within an engine family should have similar bore and stroke specifications [Reference 2, Part 1, Section 17(b)(1)]. If the bore and stroke specifications vary, they are expected to vary in a manner that maintains a constant proportional relationship. The ARB believes that for a similar engine configuration, higher bore-to-stroke ratios are indicative of lower power production efficiencies. Since the emission standards are specific with respect to an engine's power output (efficiency), an engine with a lower efficiency will produce higher specific emission values. Therefore, an engine manufacturer should select, within the same engine family, a candidate engine with the highest bore-to-stroke ratio. When candidate engines with the same bore-to-stroke ratio are available, the engine manufacturer should select the lowest displacement engine.

B. Fuel System

When more than one variety of a carburetor is used in an engine-system combination, the engine manufacturer should select the engine equipped with the carburetor which has the smallest venturi size (a smaller venturi size corresponds to a lower maximum power output, hence higher specific emissions) as the test engine. Some engine families may utilize fuel systems which use adjustable carburetors in order to compensate for environmental conditions, engine wear or the ultimate end-use requirements. In this scenario, the test results from these adjustable carburetors should reflect data obtained by testing the engines at the extremes of the possible carburetor adjustments. In other words, the exhaust emission testing should be conducted at both the leanest and richest settings.

C. Air Cleaner

The power production efficiency of an engine will decrease as the air cleaner becomes more restrictive. Lower efficiency would be indicative of higher specific emission values. Therefore, when candidate engines are available with varying types of air cleaners, the engine configuration using the most restrictive air cleaner should be selected. For four stroke engines, if there is a five percent or greater difference in power production between two possible engine configurations, engine manufacturers should select the configuration with the lowest power output. For engine configurations with less than a five-percent difference, the engine manufacturer may select either configuration. For two stroke engines, engine manufacturers should select the most restrictive air cleaner.

D. Exhaust Systems

Exhaust back pressure affects an engine's power output. Consequently, the engine configuration which produces the lowest power output would have the highest specific emissions. For four stroke engines, if there is a five percent or greater difference in power production between two possible engine configurations, engine manufacturers should select the engine configuration with the lowest power output. For engine configurations with less than a five-percent difference, the engine manufacturer may select either configuration. For two stroke engines, engine manufacturers should select the engine configuration with the highest back pressure.

Policy: 2. Test Engine Selection for Incomplete Engine Subassemblies

Where the final-assembly engine configuration may use a variety of models of mufflers, air cleaners, etc., testing every possible engine configuration within the engine family could require a large number of certification tests. In such a case, an engine manufacturer will be allowed to propose and request ARB's approval to designate certain component models as standard component models. The performance of the standard component model should be such that it could be considered representative of the performance of the other similar component models. These standard component models should be utilized in the final-assembly engine for certification testing of an engine family. Such standard components should be selected on the basis of their anticipated propensity of producing an engine configuration with the greatest probability of exceeding the emission standards, and should be selected using the method outlined previously in the test engine selection policy. Additionally, engine manufacturers should provide the supporting data and rationale for the standard component model selection with the request. Nonetheless, the use of standard component models in certification does not relieve an engine manufacturer of emission compliance obligations for all completed and marketed equipment engines that may use component models that are different from the selected standard component model.

TAMPER RESISTANCE

Background: Production engines are required to be representative of the certification engines with respect to the fuel system, emission control system components, exhaust after-treatment devices or components that can reasonably be expected to influence exhaust emissions [Reference 2, Part I, Section 30(a)(2)(i)(A)]. As such, the production engines should exhibit similar performance and emission characteristics as the certification engines; they must comply with the emission standards in use for their useful lives.

Discussion: Adjustments to some emission related components by an end-use operator may be required in order to allow for satisfactory performance. For example, a carburetor may require adjustments so that the engine will continue to operate effectively with changes in elevation, temperature, engine wear, etc. Such adjustments are acceptable if they are allowed by the engine manufacturer and they do not go beyond the engine manufacturer's design limits. As stated previously in the Test Engine Selection policy, a candidate engine which uses an adjustable carburetor should be tested at the extremes of the allowable adjustments (See Criteria B - Fuel System, Policy 1. Engine Family Test Engine Selection).

<u>Policy</u>: 3. <u>Tamper Resistance of Engines With Adjustable Parameters</u>

Emission related physically and electronically adjustable parameters on certified engine configurations should be designed and manufactured in order to restrict and inhibit in-use changes to the manufacturer-certified calibrations, and inappropriate replacement or modification to components. In order to minimize the occurrences of accidental in-use maladjustments and to discourage in-use tampering of engine manufacturer's configurations, the ARB requires engine manufacturers to provide sufficient safeguards for adjustable parameters.

The ARB recognizes that there may be various methods with which to safeguard an adjustable parameter. The use of any of these methods requires ARB's approval. The ARB will determine the adequacy of tamper resistance measures based on consideration of conditions such as those listed below. Engine manufacturers should note that it is not necessary for an individual adjustable parameter to satisfy all of the following conditions. In most situations, satisfying only one condition will probably provide a sufficient safeguard measure. These conditions include:

a) The physical device which controls the adjustable parameter may be accessible only by disassembly of the equipment or engine, and this disassembly requires the use of special tools.

b) The physical device which controls the adjustable parameter is restricted from movement beyond the engine manufacturer's design range, and the restriction is circumvented only through the use of special tools. In other words, attempts to adjust the physical device beyond the design range may result in breakage of the device and lead to unsatisfactory engine operation which may cause the operator to seek service.

c) Any attempted adjustments of the adjustable parameter beyond the engine manufacturer's design range are ineffective.

d) Access to integrated circuits used in an engine management system is possible only through the use of special tools. Any programmable coding used in an engine management system is protected adequately against inappropriate revisions.

The ARB believes that engine manufacturers will probably not demonstrate adequate deterrence to tampering by requiring the removal of a component (such as, an air cleaner) that is routinely removed during standard maintenance and whose removal is required prior to making the adjustment.