

State of California
AIR RESOURCES BOARD

STAFF REPORT: INITIAL STATEMENT OF REASONS

**PROPOSED AMENDMENTS TO THE
CALIFORNIA ON-ROAD MOTORCYCLE REGULATION**

Date of Release: October 23, 1998
Scheduled for Consideration: December 10, 1998

Mobile Source Control Division
9528 Telstar Avenue
El Monte, California 91731

This report has been prepared by the staff of the California Air Resources Board. Publication does not signify that the contents reflect the views and policies of the Air Resources Board, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ACKNOWLEDGMENTS

The ARB staff extend their appreciation to the staffs of BMW, Harley-Davidson, Honda, Kawasaki, Suzuki, Triumph, and Yamaha, for providing technical data and feedback on our proposals under an ambitious rulemaking schedule. We would also like to thank the members of the Manufacturers of Emission Controls Association, who provided valuable data on the current and emerging state of emissions control technologies. Moreover, we thank the Motorcycle Industry Council, the California Motorcycle Dealers Association, and the American Motorcyclist Association, for facilitating discussions with their members. We are particularly grateful to the Motorcycle Industry Council, for the feedback the Council provided from small-volume-manufacturer members and for the extensive statistical data and analyses provided, which helped refine the emissions inventory.

TABLE OF CONTENTS

	<u>Page</u>
EXECUTIVE SUMMARY	1
I. INTRODUCTION	I-1
II. BACKGROUND	II-1
A. Vehicle Classes	II-1
B. History of the Existing Regulation	II-1
C. Current Emission Limits	II-2
D. On-Road Motorcycle Emissions	II-2
III. RULE DEVELOPMENT PROCESS AND PUBLIC OUTREACH EFFORTS	III-1
A. Individual Meetings	III-1
B. Meetings with Industry Trade and Motorcycle Riders' Groups	III-3
C. Public Workshops	III-3
IV. SUMMARY OF PROPOSED AMENDMENTS	IV-1
A. Tier-1/Tier-2 Exhaust Emission Standards	IV-1
B. Corporate Averaging	IV-3
C. Small Volume Manufacturer Provision	IV-4
V. TECHNOLOGICAL FEASIBILITY OF PROPOSED STANDARDS	V-1
A. Analysis Methodology	V-1
B. Meeting the Tier-1 Standard: Engine Modifications and Other Non-Catalyst Technologies to Reduce Engine-Out Emissions	V-2
C. Meeting the Tier-2 Standard: Using Engine Systems and Catalytic Converters	V-5
D. Safety	V-10
VI. COMMERCIAL FEASIBILITY AND ECONOMIC IMPACTS OF PROPOSED STANDARDS	VI-1
A. Summary of Economic Impacts	VI-1
B. Legal Requirements	VI-1
C. Businesses Affected	VI-2
D. Potential Impacts on California Businesses	VI-3
E. Potential Impacts on Business Competitiveness	VI-5
F. Potential Impacts on Employment	VI-5
G. Potential Impact on Business Creation, Elimination, or Expansion	VI-5
H. Potential Impacts on Consumers	VI-6
I. Economic Impacts on California State or Local Agencies	VI-6
J. Cost-Effectiveness of the Proposed Standards	VI-7

TABLE OF CONTENTS (cont.)

	<u>Page</u>
VII. ENVIRONMENTAL IMPACTS OF PROPOSED AMENDMENTS	VII-1
A. Projected Benefits	VII-1
B. Potential Mitigating Factors	VII-2
VIII. ANALYSIS OF REGULATORY ALTERNATIVES	VIII-1
A. Adopt No New Standards	VIII-1
B. Adopt Less Stringent Standards	VIII-2
C. Adopt More Stringent Standards	VIII-2
D. Conclusions	VIII-3
IX. OUTSTANDING ISSUES	IX-1
A. Magnitude of Reductions and Appropriateness of Obtaining the Reductions from On-road Motorcycles	IX-1
B. Certainty in Development of Tier-2 Compliant Technology	IX-2
C. Potential Impacts on Program Effectiveness from Equipment Tampering	IX-3
X. FUTURE ACTIVITIES	X-1
A. Further Refinement of the Emissions Inventory	X-1
B. 2006 Progress Review	X-1

REFERENCES

APPENDIX A:	Proposed Amendments to the On-Road Motorcycle Regulation
APPENDIX B:	Requests for Consultation, Requests for Information
APPENDIX C:	Meeting & Workshop Notices, Attendees' Lists

LIST OF TABLES

<u>Title</u>	<u>Page</u>
Table II-1. Motorcycle Classes by Engine Displacement	II-1
Table II-2. Official Statewide Inventory & Updated Staff Emission Estimates for On-road Motorcycles	II-2
Table III-1. Individual Meetings with Medium/High-Volume Motorcycle Manufacturers	III-1
Table III-2. Small-Volume Manufacturers & Parts Suppliers Contacted by ARB Staff	III-2
Table IV-1. Multipliers to Encourage Early Compliance with the Proposed Tier-2 Standard and Beyond	IV-4
Table V-1. Breakdown of HC Certification Levels by Technology and Market Share	V-5
Table VI-1. Major Manufacturers in the Motorcycle Industry	VI-2
Table VI-2. Component Costs to Comply with Staff Proposal (Relative to 1998 Models)	VI-10
Table VI-3. Estimated Advanced Vehicle Technology Research Costs	VI-12
Table VI-4. Estimated Vehicle Development Costs	VI-13
Table VI-5. Estimated Capital Recovery Costs	VI-13
Table VI-6. Estimated Dealer Costs	VI-14
Table VI-7. Incremental Cost of Staff Proposal Over Cost of Current Standard	VI-15
Table VII-1. 2010 On-Road Motorcycle Statewide and SoCAB Emission Inventories	VII-2
Table VII-2. Projected Tier-1 and Tier-2 HC+NOx Emission Benefits	VII-2

EXECUTIVE SUMMARY

In 1994, the Air Resources Board (ARB) approved a revision to the State Implementation Plan that contains clean air strategies needed to meet the health-based, 1-hour federal ozone air quality standard (“ozone SIP”). The ozone SIP includes measures to reduce emissions from mobile sources under State control (including cars, heavy-duty trucks, off-road equipment), as well as federal assignments to control emissions from sources under exclusive or practical federal control (such as airplanes, marine vessels, and locomotives). The ozone SIP also relies upon the development of additional technology measures (the mobile source “black box”) to provide additional emission reductions needed for attainment in the South Coast Air Basin.

Although on-road motorcycles have been regulated since 1978, the 1994 ozone SIP does not include specific new control measures for on-road motorcycles. The staff’s proposal to further reduce emissions from on-road motorcycles is a new measure reflecting reasonably available and emerging technologies. The staff’s proposal offers additional, cost-effective emission reductions which will further progress toward meeting the federal ambient standard for ozone. The additional emission reductions will also contribute to continued progress toward meeting State and new federal air quality standards for ozone and particulate matter.

On-road motorcycles represent a source of potential emission reductions because motorcycles emit from 10 to 15 times more pollutants per mile traveled than current model cars. This is because the existing on-road motorcycle regulation reflects emission controls that are about 15 or more years old. Therefore, we approached this rulemaking with the goal of developing standards that reflect up-to-date, reasonably available, and demonstrated control technologies, as well as emerging technologies.

The staff’s proposal affects all new, Class III motorcycles produced after the specified compliance dates. In this rulemaking, Class III includes those on-road motorcycles which have an engine displacement of 280 cubic centimeters or greater. The proposal includes a two-tier set of standards which progressively lower exhaust emissions of hydrocarbons (HC) and oxides of nitrogen (NO_x). We are not proposing to regulate motorcycle carbon monoxide (CO) or evaporative emissions beyond the existing requirements.

In the short term, the proposed Tier-1 HC+NO_x standard of 1.4 g/km HC+NO_x reflects the goal of achieving emission reductions that could be met with reasonably available control technologies, primarily involving engine modifications rather than catalytic converters. We are proposing that the Tier-1 standard be effective for the 2004 model year. A number of existing engine families already comply with this standard or would need relatively simple modifications to comply. In other cases, the manufacturers will need to use control technologies that are available but are not yet used on their particular vehicles (e.g., electronic fuel injection to replace carburetors, changes to cam lobes/timing, etc.). For the most part, manufacturers will not need to use advanced technologies such as close-coupled, closed-loop three way catalysts. Because advanced technologies are generally not needed to meet the Tier-1 standard, manufacturers will

be able to gradually replace at lower cost their older, higher-polluting engine families with those modified to emit less.

In the long term, we are proposing a Tier-2 HC+NO_x standard of 0.8 g/km that will ensure manufacturers will continue to advance the status of control technologies. We are proposing the Tier-2 standard to be effective by the 2008 model year. This standard will present some challenges for manufacturers; however, several manufacturers are already using some of the technologies that will be needed to meet this standard. One manufacturer already uses closed-loop, three-way catalysts on several of its product lines. Other manufacturers have products in the market with emission levels close to the Tier-2 standards using two-way catalysts, fuel injection, secondary pulse-air injection, and other engine modifications. We expect manufacturers to optimize these existing advanced technologies and others to meet the Tier-2 standard in the nine years that remain before the standard takes effect.

Although the Tier-1 standard will achieve some reductions, the majority of emission reductions to be gained by this rulemaking will come from the implementation of the Tier-2 standard. We estimate the full implementation of these two standards will reduce HC+NO_x emissions by approximately 1.3 TPD by 2010, and 2.9 TPD by 2020. We based our estimates of the proposal's benefits on an updated emission inventory which includes various refinements provided by the Motorcycle Industry Council (MIC) and data from ARB's in-use compliance program, certification database, and the current surveillance project. Because the Tier-2 standard achieves most of the expected benefits from this rulemaking, that standard plays a critical role in the overall effectiveness of the proposed amended motorcycle regulation.

While they are challenging, the proposed standards are not only technologically feasible, they are also commercially feasible and cost-effective. For the Tier-1 standard, we estimate a sales-weighted average production cost increase of up to \$44 per motorcycle relative to a new 1998 motorcycle. This reflects research and development, capital recovery, dealership costs, and the use of engine modifications such as replacing carburetors with fuel injection. With the increased use of catalytic converters, the Tier-2 standard should result in a sales-weighted average production cost increase of about \$97 per motorcycle relative to a new 1998 motorcycle. Thus, the overall sales-weighted average production cost increase we estimate for this rulemaking is less than \$100 per motorcycle upon full implementation of the standards. However, some of the cost increases consumers may experience will likely be offset to a degree by savings resulting from better fuel management and less required maintenance. Based on the expected emission reductions, this cost increase translates to an overall cost-effectiveness ranging from about \$3.00 to \$5.60 per pound of HC+NO_x reduced, which is within the range of other emission control measure costs.

We expect the proposed two-tier standards will have economic impacts primarily on six major manufacturers (BMW, Harley-Davidson, Honda, Kawasaki, Suzuki, and Yamaha), all headquartered outside of California. Because of the relatively long timeframe manufacturers will have for meeting the standards, we expect little or no economic impacts to distributors or

retailers; the 2004 and 2008 timeframes should provide adequate time for these businesses to adapt their marketing plans and adjust their inventories accordingly. We expect some economic benefits for manufacturers of components that help meet the standards, as they increase both their production of such components and their workforce to meet the demand. The standards should also benefit companies that test engines or provide consultation to those manufacturers that outsource those types of activities.

While we expect little or no impacts to low-volume manufacturers from the Tier-1 standard, we believe the Tier-2 standard would significantly impact the small-volume manufacturers. For the purposes of this rulemaking, we are defining small-volume manufacturers as those which sell no more than 1,000 Class I, II, and III motorcycles (combined) in California for a model year. These small-volume manufacturers collectively represent less than 5% of the total market for new motorcycles in California. As such, they generally have neither the financial nor technical resources to develop engine families that can meet the Tier-2 standard. On the other hand, even the small-volume manufacturers should be able to apply existing, reasonably available and demonstrated technology to meet the Tier-1 standard by 2008. Therefore, the staff proposes to apply the 2004 Tier-1 standard to all manufacturers (with four additional years to 2008 for the small-volume manufacturers) and to exempt small-volume manufacturers from the Tier-2 standard.

To provide incentives for early compliance with the Tier-2 standard, staff is proposing a set of multiplier factors that provide extra credit to manufacturers that introduce motorcycles which meet the Tier-2 standard earlier than the 2008 model year. Based on our belief that at least some of the manufacturers can reach levels significantly lower than the Tier-2 standard, we are also proposing a set of multipliers for early introduction of motorcycles certified at 0.4 g/km HC+NO_x or less. Use of these credits will make it easier for a manufacturer to comply with the corporate emissions average standard in 2008.

Based on the commercial and technological feasibility of the standards, as well as the projected emission benefits, we recommend that the Board adopt the staff proposal.

I.

INTRODUCTION

Significant strides have been made toward improving California's air quality. Nonetheless, regions throughout California continue to exceed health-based state and federal air quality standards. Areas exceeding the State and federal 1-hour ozone standard include the South Coast Air Basin, San Diego County, the San Joaquin Valley, the Southeast Desert, the Broader Sacramento area and Ventura County. As the new federal eight-hour ozone standard is implemented, more areas of the State are likely to be designated as nonattainment for ground-level ozone.

Created by the photochemical reaction of reactive organic gases (ROG) and oxides of nitrogen (NOx), ozone causes harmful respiratory effects including lung damage, chest pain, coughing, and shortness of breath. Ozone is particularly harmful to children, the elderly, athletes, and persons with compromised respiratory systems. Other environmental effects from ozone include substantial damage to crops, buildings, and other structures.

In addition, ozone precursors contribute to ambient levels of respirable particulate matter (PM₁₀). NOx reacts in the atmosphere to form part of the nitrate fraction in PM₁₀. ROG emissions resulting from incomplete combustion also contribute to PM₁₀ formation through condensation or other atmospheric processes. Thus, reductions in ozone precursors, particularly NOx, will be crucial to meeting existing state and federal PM₁₀ standards, as well as the new federal standards for fine particulate matter (PM_{2.5}).

California's plan for achieving the federal 1-hour ozone standard is contained in the California State Implementation Plan for Ozone (ozone SIP) that was approved by the Board in 1994. A significant part of the ozone SIP pertains to the control of mobile sources, which are estimated to account for approximately 70 percent of ozone precursor emissions statewide. The ozone SIP calls for new measures to cut ozone precursor emissions from mobile sources to half of what the emissions would be under existing regulations.

Beyond the specific measures identified when it was adopted, the ozone SIP for the South Coast Air Basin (an extreme ozone-nonattainment area) relies on the development of additional technology measures as allowed in Section 182(e)(5) of the Clean Air Act Amendments of 1990. Under the so-called "black box" provisions of Section 182(e)(5), the ozone SIP calls for additional motor source emission reductions in the South Coast Air Basin of approximately 75 tons per day (tpd) ROG plus NOx. These reduction commitments, while not assigned to a specific mobile source sector, must nevertheless be met for the South Coast Air Basin to attain the federal ozone air quality standard by the required 2010 deadline.

ARB staff have identified on-road motorcycles as a technologically-feasible, cost-effective source of additional emission reductions. The additional emission reductions would cover shortfalls in defined ARB measures and make progress on the black box. Although the South Coast Air Basin is the only area of the State with a black box, the emission reductions are needed statewide. The proposed on-road motorcycle regulation will help achieve and maintain the federal 1-hour ozone standard in regions such as the San Joaquin Valley and the Sacramento area; the federal 8-hour ozone and particulate matter standards in a number of areas; and the State ozone and particulate matter standards throughout California.

This Staff Report is organized to demonstrate the commercial and technological feasibility of the staff's proposal, as well as its cost-effectiveness and benefits. Chapter II provides background information as well as a discussion of the current on-road motorcycle regulation. Chapter III describes the rulemaking process staff used to develop the proposal, including the staff's public outreach efforts. Chapter IV provides a plain English discussion of the proposed amendments to the regulation, as shown in Appendix A. Chapter V discusses the technological feasibility of the proposed standards, while Chapters VI and VII demonstrate the commercial feasibility and economic and environmental impacts we expect from the proposal. Chapter VIII compares regulatory alternatives we evaluated prior to presenting our proposal to the Board. Chapter IX discusses the main outstanding issues raised during the rulemaking. Finally, Chapter X outlines some of the future activities ARB staff plan to undertake in the future, either as a formal part of this proposal or as a follow-up to some of the concerns raised by affected stakeholders.

II.

BACKGROUND

A. Vehicle Classes

Motorcycles come in various configurations using two-wheeled, three-wheeled, and even four-wheeled designs. However, for the purposes of this report, motorcycles for the most part are two-wheeled, self-powered vehicles. The key parameter that distinguishes a motorcycle from a moped is the engine displacement: a moped has an engine displacement of less than 50 cubic centimeters (cc), while motorcycle engines displace 50 cc or greater. In California, engine displacement is used to further categorize motorcycles, as shown in Table II-1.

Table II-1. Motorcycle Classes by Engine Displacement

Motorcycle Class	Engine Displacement, (cubic centimeters)
Class I	50 to 169 cc
Class II	170 to 279 cc
Class III	280 cc and greater

The current market in California strongly favors the larger displacement Class III motorcycles; over 90% of all new motorcycles sold in California are in this category. These include street-legal versions of racing bikes (“sport” bikes), heavily outfitted highway “cruisers,” and the retro/neo-classically styled “custom” bikes. Most, if not all, of the projected growth in new motorcycle sales are expected in the Class III sector. Because of this, we focused our rulemaking efforts on this particular subcategory.

B. History of the Existing Regulation

The ARB adopted the first on-road motorcycle regulation in 1975. See Title 13, California Code of Regulations, Section 1958. The regulation established exhaust and evaporative emission standards for HC and CO beginning with the 1978 model year. Depending on the motorcycle engine size, the original HC exhaust standards ranged from 5.0 grams per kilometer (g/km) to 14.0 g/km.

In 1984, the ARB amended the model year 1985 HC exhaust standard to give manufacturers more flexibility. The new standards for model year 1985 and beyond focused on the Class III category (280 cc and above): 280 to 699 cc engines were limited to 1.0 g/km for model years, while 700 cc and larger motorcycles were limited to 1.4 g/km HC. The ARB established provisions to allow manufacturers to meet these limits on a “corporate average” basis, with no individual engine family allowed to exceed 2.5 g/km HC.

Additionally, in 1984 the Board directed the ARB staff to revisit the regulation when catalytic and other emissions control technologies had matured to the point that it would be feasible to apply these technologies to on-road motorcycles. (ARB, 1984) Significant strides in controlling emissions from internal combustion engines have taken place since then, with developments in the automotive sector gradually being applied to motorcycles. This is particularly true in Europe and Asia, where engine modifications, fuel injection, secondary pulse-air injection, and catalytic converters are used in significant numbers of on-road motorcycles. On the other hand, the ARB emission standards for motorcycles have not kept pace with the rate at which emission control technologies have developed. Therefore, ARB staff believe it is appropriate to amend the existing standards to the proposed levels, which reflect the use of reasonably available technologies.

C. Current Emission Limits

As noted previously, Class III motorcycles are currently subject to one of two HC-only limits, depending on engine size: 1.0 g/km for engines from 280 to 699 cc, and 1.4 g/km for 700 cc or greater engines. No more than 2.0 grams per test of HC evaporative emissions are allowed under the test procedure specified in the regulation. The regulation does not currently limit emissions of oxides of nitrogen (NOx). It should also be noted that on-road motorcycles are currently exempted from the inspection and maintenance program (i.e., the “Smog Check” program) which automobiles and other vehicles undergo on a regular basis. See 13 CCR 1958.

D. On-Road Motorcycle Emissions

The current official emissions inventory for on-road motorcycles is based on outdated U.S. EPA data and is therefore subject to uncertainty. There is some evidence which indicates the official inventory may overestimate statewide emissions from on-road motorcycles. ARB staff have therefore developed an updated and improved emissions inventory for these vehicles.

The ARB staff-updated inventory and the current official inventory (ARB, 1995) are shown in Table II-2 for comparison. Even with the updated information, Table II-2 clearly shows that on-road motorcycles represent a significant source of ozone precursor emissions.

Table II-2. Official Statewide Inventory & Updated Staff Emission Estimates for On-Road Motorcycles

Ozone Precursor	Baseline Inventory for 2010, TPD	
	Official Inventory	Current ARB Staff Estimate
HC	9.6	4.6
NOx	4.9	3.1
HC+NOx	14.5	7.7

Note: Official inventory based on EMFAC7G. Current ARB staff estimate based on 7G revised with usage statistics from MIC; recent DMV vehicle motorcycle registrations; updated parameters from 7X (internally-available draft EMFAC); and data from ARB’s in-use compliance program, certification database, and current surveillance project.

III.

RULE DEVELOPMENT PROCESS AND PUBLIC OUTREACH EFFORTS

A. Individual Meetings

Because only six manufacturers represent over 95% of all new motorcycle sales in California, we began this rulemaking process with the goal of meeting individually with those companies: BMW, Harley-Davidson, Honda, Kawasaki, Suzuki, and Yamaha. We took this approach because: (1) given the diversity of company locations, it was more efficient to meet individually than meeting as a group, (2) as large companies and market leaders, these manufacturers were presumed to have the financial and technical resources to investigate the feasibility of the staff's proposals, and (3) individual meetings are more conducive to a frank and open discussion of the proposals, proprietary information, and associated issues. On numerous occasions, we asked to meet with manufacturers and other stakeholders in writing and by telephone (see Appendix B); the dates we met with each manufacturer are shown in Table III-1. After every meeting, we reiterated our openness to discussing any issues the manufacturers raised and to meet again as often as they desired.

Table III-1. Individual Meetings with Medium/High-Volume Motorcycle Manufacturers

Manufacturer	Meeting Dates in 1998
BMW	April 27, May 27
Harley-Davidson	April 29, July 17, Sept. 1
Honda	March 24, May 22, July 21
Kawasaki	March 13
Suzuki	March 2
Yamaha	March 3, June 18

In addition to meeting with the large manufacturers, we took reasonable actions to meet with and present our proposals to smaller companies. First, we phoned and mailed written requests for meetings to several small-volume manufacturers, with a particular emphasis on companies located in California (Ryden, 1998); these companies are shown in Table III-2. Only one small-volume manufacturer, Triumph (located in England), agreed to meet individually with staff. The three meetings we had with Triumph were very informative because they provided insight into issues and concerns particular to the small-volume manufacturers.

Table III-2. Small-Volume Manufacturers & Parts Suppliers Contacted by ARB Staff

Aprilia Motorcycles	Goodman Motorcycles Corp.	MuZ of North America
American Motorcycle Manufacturing, Inc.	Impuls International, Inc.	Panzer Motorcycle Works
ATK America	Indian Motorcycle Manufacturing, Inc.	Polaris Industries, Inc.
California Motorcycle Company	KTM Sportmotorcycle USA, Inc.	Whizzer Motorbike
Ducati North America, Inc.	Moto Point	

Due to the apparent lack of interest in meeting individually with us, we arranged to meet collectively with smaller manufacturers on May 5, 1998, with the help of the Motorcycle Industry Council (MIC) and K.H. Wolf Consulting (an established consultant to small-volume motorcycle manufacturers). Approximately 35 stakeholders, most of whom are located in Southern California, were scheduled to attend the meeting in El Monte, California. However, only 11 industry representatives attended (see Appendix C). Despite the low attendance, we reiterated to the MIC and K.H. Wolf Consulting our willingness to meet with the small-volume manufacturers whenever they desired.

At the individual and group meetings, we provided the attendees with the basis for our proposal. We discussed our initial proposed standard of 0.2 g/km HC+NO_x, which was based on information provided by members of the Manufacturers of Emission Controls Association (MECA), a preliminary literature search we had conducted, and certification and in-use emissions data for several engine families. During each meeting, we made it clear that we were initially proposing 0.2 g/km HC+NO_x primarily to determine the lower bound of achievable emissions, which in turn helps to identify the various issues such as costs, impacts on performance, and time needed to comply. Essentially, the initial 0.2 g/km proposed limit served as a “discussion point” to help frame these issues and to focus the attendees’ efforts on determining what emission levels are achievable.

To solicit additional information, we gave each manufacturer a confidential, company-specific questionnaire designed to help us determine what is technically and commercially feasible, both on a per-company and industry-wide basis. Four of the six manufacturers provided responses to the questionnaire, which we then discussed with them in follow-up meetings. The responses to these questionnaires, along with subsequent discussions we had with the manufacturers and at the public workshops, helped to establish the staff’s current proposal using two-tier standards.

B. Meetings with Industry Trade and Motorcycle Riders' Groups

We met with several industry trade and motorcycle riders' groups to solicit comments on our proposal before we held our first public workshop. We held two meetings with the Motorcycle Industry Council (MIC), with a special emphasis on refining the existing emissions inventory using MIC's extensive market and demographics database. To illustrate, our initial inventory at the start of this rulemaking process showed approximately 9.6 tpd HC and 4.9 tpd NO_x statewide emissions from on-road motorcycles, based on computer runs using the EMFAC7G model. We initially ran this model using the built-in U.S. EPA assumptions and parameters dating back to the 1970s, which were clearly outdated. With the MIC's data, we were able to refine the inventory to better reflect vehicle miles traveled (VMT) and other vehicle activity data. Our best estimate at this point shows statewide emissions of approximately 4.6 tpd HC and 3.1 tpd NO_x. Our cooperative efforts with the MIC to further refine the inventory will continue in the future as better data become available (see Chapter X).

In addition to meeting with the MIC, we also met with the California Motorcycle Dealers Association and the American Motorcyclist Association to discuss their concerns about the proposal. Their concerns mainly involved the proposed standards' possible impacts on driveability, cost, and availability of product lines. We discussed the staff proposal and emphasized that the standards are strictly performance-based; that is, manufacturers can sell any engine family based on any design as long as the motorcycles meet the standards. Because our analysis shows the standards are feasible and cost-effective, we discussed our expectation that manufacturers would be able to offer the same variety of motorcycle engine families that are available today. We also reiterated our goal of working with the manufacturers to develop standards which will not have significant impacts on cost, horsepower, driveability, aesthetics, rider safety, and any other concerns riders and dealers have. Finally, we discussed the need to reduce or minimize the rate of equipment tampering by consumers.

C. Public Workshops

Based on our individual and group meetings with stakeholders, we revised our original proposal of a single 0.2 g/km HC+NO_x to a progressive, dual-standard proposal. We revised our proposal three times to reflect a better understanding of the challenges involved and to address industry's concerns. At the first workshop on July 1, 1998, we proposed a revised set of standards for further discussion: a Tier-1 standard between 0.6 and 0.8 g/km HC+NO_x, effective between 2004; and a Tier-2 standard between 0.3 and 0.4 g/km, effective 2008. (ARB, 1998a) The ranges in proposed emission limits reflected the need for additional information at that time. From subsequent meetings, we were better able to project a new set of standards and expected compliance dates. Therefore, we further revised our proposal, which we discussed with stakeholders at a second workshop on October 7, 1998 (ARB, 1998b): a 1.2 g/km HC+NO_x Tier-1 standard effective for Model Year 2004 and a 0.4 g/km HC+NO_x Tier-2 standard effective for Model Year 2008.

Based on further input obtained from stakeholders at this workshop, we developed our final proposal: a 1.4 g/km HC+NO_x Tier-1 standard effective for Model Year 2004 and a 0.8 g/km HC+NO_x Tier-2 standard effective for Model Year 2008. Our final proposal also provides small-volume manufacturers additional time (to Model Year 2008) to comply with the Tier-1 standard of 1.4 g/km HC+NO_x, with no subsequent standard. The small-volume manufacturer provision is similar to the MIC's suggested provision and reflects a careful balancing between three competing factors: (1) the fact that these companies lack the capital to conduct the necessary research and development to meet the more-stringent Tier-2 standard, (2) the need to avoid giving small manufacturers an unfair competitive advantage over manufacturers who are subject to the Tier-2 standard, and (3) the need to achieve equitable and feasible reductions from all on-road motorcycles.

IV.

SUMMARY OF PROPOSED AMENDMENTS

A. Tier-1/Tier-2 Exhaust Emission Standards

As noted previously, our proposal applies to Class III motorcycles (those with engine displacement of 280 cc or greater). The vast majority of new motorcycle sales in California (over 90%) are in the Class III sector (MIC Statistical Annual, p.1; projected 1998 sales from ARB on-road motorcycle certification database); all available sales trends and projections strongly indicate that nearly all sales growth for the foreseeable future will remain in the Class III sector. (*Id.*) Therefore, it is reasonable to assume that new, lower emission standards for Class III motorcycles will achieve the most emission benefits at the least cost. Motorcycles with engines smaller than 280 cc will remain subject to the existing 1.0 g/km HC and 12 g/km CO standards.

Unlike the existing regulation, the ARB staff's proposal would regulate both HC and NOx emissions. Because both pollutants are ozone precursors, the proposal would reduce ozone formation from motorcycle emissions more effectively than the existing HC-only standard. Moreover, the staff's proposed combined HC+NOx standards provide more flexibility to manufacturers than individual HC and NOx standards would. This added flexibility results from the manufacturers' ability to balance HC versus NOx emissions in each engine family; because HC and NOx emissions are inversely proportional, companies can use this balancing to help meet their performance goals while optimizing reductions in HC and NOx levels.

The second main difference is the proposal's use of a two-tier set of standards. Under the existing regulation, manufacturers only had to meet standards that were developed in the late 1970s and early 1980s. As a result, manufacturers have not had a strong incentive to modernize their emissions control technologies at the same pace as automobiles and other motor vehicles. Our proposal applies a two-stage set of standards to avoid a similar stagnation of control technology development and to progressively reduce emissions over the next 20 years.

The first tier standard (Tier-1) of 1.4 g/km HC+NOx would apply to Class III model years 2004 through 2007. As noted previously and in Chapter V, staff is proposing the Tier-1 standard at a level which is achievable with reasonably available and demonstrated emission controls without relying on catalytic after-treatment. That is, we are proposing the 1.4 g/km standard so that manufacturers can meet it by reducing their engine-out emissions using mostly engine systems (fuel injection, pulse air injection, valve overlap changes, etc.), rather than relying on catalytic after-treatment of the exhaust. It is important to note that the proposed Tier-1 standard is very close to the MIC's recommended 1.5 g/km Tier-1 and 1.2 g/km Tier-2 standards (MIC, 9/98), and it is identical to Harley-Davidson's recommended 1.4 g/km HC+NOx standard for the 2004 model year. (Hoelter, 1998)

The proposed second tier standard (Tier-2) would limit emissions to 0.8 g/km HC+NO_x. This proposed standard will apply to model years 2008 and beyond. As discussed in Chapter V, this standard represents some challenges to industry, but available information strongly indicate that this is a commercially and technologically feasible emissions level. We expect manufacturers to modify and optimize existing technologies to achieve this level. Technologies that will help meet this standard include computerized fuel injection; high-efficiency, closed-loop, two or three-way catalytic converters; precise air-fuel (A/F) ratio controls; programmed secondary pulse-air injection; low-thermal capacity exhaust pipes; and other technologies which are available today or in the foreseeable near-future.

We are proposing the 0.8 g/km Tier-2 standard to address several issues, one of which is the consumer tampering issue raised by industry during this rulemaking (see Chapter IX, “Outstanding Issues”). Basically, the industry is concerned that standards which result in the widespread use of catalysts will achieve less benefits than projected due to consumer tampering or migration/tourism of non-California-compliant motorcycles from other states. On some motorcycle lines, particularly with certain custom and sport bikes, consumer tampering is projected to occur at rates of 34% or greater (MIC, 1998). Such tampering, which can involve the replacement of exhaust pipes that may include the catalytic converter, can offset some of the emission benefits to be achieved by the proposed standards. Migration or tourism involving 49-state motorcycles can also impact projected emission benefits to the extent that manufacturers bifurcate their production into California-only and 49-state motorcycles.

Our proposed 0.8 g/km Tier-2 standard addresses both of these concerns. The 1998 ARB on-road motorcycle certification database shows that about one-third of new motorcycle sales are in the sport bike category; the MIC stated that this category is most likely to experience the highest levels of tampering due to the consumers’ desire to maximize horsepower (e.g., removal of exhaust after-treatment equipment). Based on our review of the motorcycles in the 1998 certification database, we project that about 40% of the market can be left at the 1.4 g/km non-catalyst-based level (i.e., no additional modifications needed after the Tier-1 level), while the remaining 60% would likely use catalytic converters to certify at 0.4 g/km HC+NO_x, or a similar level. Under corporate averaging, manufacturers will be able to sell higher-emitting motorcycle lines, such as sport bikes, to those consumers who are most likely to tamper with their motorcycles, while selling catalyst-based motorcycle models, such as cruisers, to consumers who are less likely to tamper with the equipment. Therefore, with corporate averaging at 0.8 g/km Tier-1 standard, the effects of consumer tampering and migration of higher-emitting, 49-state motorcycles can be reduced.

B. Corporate Averaging

To provide flexibility in meeting the standards, we are proposing to maintain the corporate averaging provisions in the existing regulation for HC and NO_x. To ensure that no backsliding on the existing standards can occur, we propose to modify the existing “cap” that applies to individual engine families so that: (1) it is expressed in HC+NO_x grams per kilometer, and (2) it decreases when the standards decrease from Tier-1 to Tier-2.

Under the existing corporate averaging provisions, manufacturers can balance the certified emissions of their motorcycles so that the sales-weighted average certified emissions level meets the applicable standard. This means that some engine families may have emissions below the standards, while others have emissions higher than the standards. For enforcement purposes, manufacturers are required to specify a certification limit for each engine family. For example, one of a manufacturer’s Class III engine families may be certified as emitting 1.7 g/km HC; this is allowable if the average of all the manufacturer’s engine families meets the currently applicable 1.4 or 1.0 g/km HC standard.

To maintain equity, the Board also adopted a not-to-exceed cap of 2.5 g/km HC for all individual engine families under the existing regulation’s corporate averaging provision. Because the 2.5 g/km HC-only standard was the standard in effect before corporate averaging was adopted, the 2.5 g/km cap prevents manufacturers from selling motorcycles under corporate averaging with emissions that are higher than the previous standard, which would give such manufacturers a potentially unfair performance and competitive advantage. Based on this reasoning, we are proposing a similar cap. Thus, for both Tier-1 and Tier-2 standards, we are proposing a cap on individual engine families of 2.5 g/km HC+NO_x.

To encourage early compliance, we are also proposing incentives in the corporate averaging provisions. We believe such incentives will help manufacturers decide to take whatever risks are involved in introducing new, catalyst-based, Tier-2 compliant motorcycles earlier than required by the staff’s proposal. In addition, we believe some manufacturers can reduce emissions even further than required by the Tier-2 standard; we would like to encourage the early introduction of these very low-emission vehicles. The proposal provides incentives for early compliance by assigning specific multiplier factors based on how early a manufacturer produces a Tier-2 compliant motorcycle and a motorcycle certified at 0.4 g/km HC+NO_x ; these multipliers are shown in Table IV-1.

Because we expect the Tier-2 technologies to become more widespread as 2008 approaches, the multipliers decrease linearly in value from 2004 until 2008, when the early compliance incentive would no longer have any value (i.e., the multiplier has a value of 1.0). As shown in Table IV-1, each unit of Tier-2 early compliant motorcycles (those certified at 0.8 g/km HC+NO_x) would count as X motorcycles at 0.8 g/km HC+NO_x for purposes of corporate averaging in 2008, where X is 1.5 for those motorcycles sold during model years (MY) 1999 through 2004, 1.375 for those sold in MY 2005, 1.250 for those sold in MY 2006, 1.125 for

those sold in MY 2007, and 1.0 for those sold in MY 2008 and subsequent. A similar set of multipliers is shown in Table IV-1 for pre-MY 2008 motorcycles certified at 0.4 g/km HC+NOx.

Table IV-1. Multipliers to Encourage Early Compliance with the Proposed Tier-2 Standard and Beyond

Model Year Sold	Multiplier (X) for Use in MY 2008 Corporate Averaging	
	Early Tier-2 Compliant	Certified at 0.4 g/km HC+NOx
1999 through 2004	1.5	3.0
2005	1.375	2.5
2006	1.250	2.0
2007	1.125	1.5
2008 and subsequent	1.0	1.0

Note: Early Tier-2 compliant and 0.4 g/km certified motorcycles are counted cumulatively toward the MY 2008 corporate average

C. Small-Volume Manufacturer Provision

Small volume manufacturers collectively represent 3% of new motorcycle sales in California (MIC 1997 Motorcycle Statistical Annual, p.4). From our discussions with small-volume manufacturers, it became apparent that the proposed Tier-2 standard represents a significant, potentially infeasible limit for these manufacturers. Unlike their higher-volume competitors, small-volume manufacturers generally lack the financial and technical resources to undertake the necessary research and development (R&D) effort to meet the Tier-2 standard. Even if a small-volume manufacturer did have sufficient R&D and financial resources to investigate compliant technologies, their low sales-volume in California generally would not justify such expenditures; most, if not all, small-volume manufacturers we contacted indicated they would simply pull out of the California market.

While small-volume manufacturers are expected to have difficulty in meeting the Tier-2 standard, we believe the Tier-1 standard's reliance on engine systems would justify applying the Tier-1 standard to these companies, especially if given additional lead time to 2008. As discussed in Chapter V, the Tier-1 standard focuses on the application of reasonably available technologies that reduce engine-out emissions. These technologies include replacement of carburetors with fuel injection and relatively simple changes to the engine timing, cams, valves, or combustion chambers. We estimate a sales-weighted average production cost increase for the entire industry of about \$44 per motorcycle under the Tier-1 standard (see Chapter VI). Because small-volume manufacturers produce fewer motorcycles over which to spread their costs, we expect the average production cost increase per motorcycle to be somewhat higher for these manufacturers. However, since typical Class III motorcycles retail for about \$7,600, we would not expect a

production cost increase on the order of \$44 per unit to significantly dampen motorcycle sales, even sales for small-volume manufacturers.

Based on the considerations discussed above, we are proposing that the current standards remain in effect for small-volume manufacturers until model year 2008, when the 1.4 g/km HC+NO_x Tier-1 standard would become effective for those companies. With this proposal, the standards maintain equity by requiring all manufacturers to reduce their emissions to the extent feasible, given their relative ability to apply the necessary control technologies and their market share in California. The small-volume manufacturers' provision is supported by small-volume members of the MIC, as well as the larger volume manufacturers.

V.

TECHNOLOGICAL FEASIBILITY OF PROPOSED STANDARDS

A. Analysis Methodology

To determine the technical feasibility of the proposed standards, we used a variety of sources to evaluate the current and foreseeable emission control technologies for motorcycles. While no single source of information was conclusive in determining the proposal's feasibility, the use of multiple sources of information helped provide cross-checks on technology claims and ensured that the proposal is based on sound and credible developments in motorcycle technology. This section describes the various sources of information that provide the technical basis for the staff's proposal. Subsequent sections in this chapter will then describe the technologies we expect manufacturers will use to meet the proposed limits.

First, we looked at ARB's certification data to determine the current state of emission levels and, in particular, what combinations of technologies are being used to achieve those emission levels. This provided the most direct evidence of the technologies that are reasonably available and already demonstrated as feasible. We then conducted an extensive literature search, including Internet searches, to extract the latest technical reports applicable to current and projected motorcycle emission controls. This part of the analysis included a patent search for recently published inventions; while we were unable to access the German Patent Office's Internet site for a variety of reasons, we were able to download abstracts of relevant patents in the patent offices of the U.S. and Japan. We also held numerous discussions with engineers from the six major manufacturers, Triumph, and members of the Manufacturers of Emission Controls Association (MECA). Finally, we relied on our best engineering judgment to verify the technical soundness of proposed control techniques.

In our analysis, we evaluated only those technologies which manufacturers already use on motorcycles or have a high probability for mass-market application. Thus, we did not evaluate electric or hybrid-electric drives, non-gasoline-based power plants, electrically-heated catalysts, and other exotic technologies being investigated for use on automobiles. The pollution control techniques we evaluated can be separated into two categories: those which do not use catalytic converters (e.g., engine modifications and secondary pulse-air injection) and those that use catalytic converters (non-honeycombed "Hot Tubes," two-way and three-way catalysts). With the available information, we conclude that manufacturers can comply with the Tier-1 standard primarily with non-catalytic engine modifications and secondary pulse air injection, using low-efficiency catalytic converters only for some of the higher-polluting engine families. This conclusion is consistent with the MIC's findings that an HC+NO_x level close to staff's Tier-1 proposal is feasible using non-catalytic engine systems and simple pulse-air injection. For the Tier-2 standard, we conclude that manufacturers will use some combination of engine modifications, programmed secondary pulse-air injection, and a high-efficiency three-way catalyst.

B. Meeting the Tier-1 Standard: Engine Modifications and Other Non-Catalyst Technologies to Reduce Engine-Out Emissions

Motorcycle engines come in a wide variety of designs. Most have one to four cylinders (at least one manufacturer is currently producing six cylinder motorcycles). These engines also come in different configurations (e.g., 45 to 90 degree V-twins, 3-cylinder transverse, 2-cylinder longitudinal opposed). In addition, engines can be differentiated by the performance characteristics they emphasize; e.g., some engine families produce high horsepower at high revolutions per minute (rpm), while others feature high torque at relatively low rpm. As a result of this diversity, different types of engine systems and modifications have been developed. From these, manufacturers can select different combinations of available technologies that are appropriate for their particular engine configurations. In this section, we will discuss the various types of non-catalytic techniques available for reducing emissions, focusing mainly on engine modifications and secondary pulse-air injection. It is important to note that this discussion is not inclusive of all engine modifications possible, nor is it intended to show that all of these modifications can be applied the same way to all engine families.

While manufacturers will use various means to meet the Tier-1 standard, there are four basic types of existing, non-catalyst-based, emission control systems available to manufacturers. The most important of these is the use of secondary pulse-air injection. Other engine modifications and systems include more precise fuel control, better fuel atomization and delivery, and reduced engine-out emission levels from engine changes. The combinations of low-emission technologies ultimately chosen by motorcycle manufacturers are dependent on the engine-out emission levels of the vehicle, the effectiveness of the prior emission control system, and individual manufacturer preferences.

Secondary pulse-air injection, as demonstrated on current motorcycles, is applied using a passive system (i.e., no air pump involved) that takes advantage of the flow of gases (“pulse”) in the exhaust pipes to draw in fresh air that further combusts unburned hydrocarbons in the exhaust. Engine modifications include a variety of techniques designed to improve fuel delivery or atomization; promote “swirl” (horizontal currents) and “tumble” (vertical currents); maintain tight control on air-to-fuel (A/F) ratios; stabilize combustion (especially in lean A/F mixtures); optimize valve timing; and retard ignition timing.

Secondary Pulse-Air Injection

This technique involves the introduction of fresh air into the exhaust pipe immediately after the gases exit the engine. The extra air causes further combustion to occur, thereby controlling more of the hydrocarbons that escape the combustion chamber. This type of system is relatively inexpensive and uncomplicated because it does not require an air pump; air is drawn into the exhaust through a one-way reed valve due to the pulses of negative pressure inside the exhaust pipe. Secondary pulse-air injection is one of the most effective non-catalytic, emissions control technologies; compared to engines without the system, reductions of 10-40% for HC are

possible with pulse-air injection. (ACEM, p.20, 1998) Thirty-five of the 87 engine families certified for sale in California this year already employ secondary pulse-air injection to help meet the current standard. We anticipate most of the remaining engine families will use this technique to help meet the Tier-1 and Tier-2 standards.

Improving Fuel Delivery and Atomization

This emissions control technique primarily involves the replacement of carburetors, currently used on most motorcycles, with more precise fuel injection systems. There are several types of fuel injection systems and components manufacturers can choose. The most likely type of fuel injection manufacturers will choose to help meet the Tier-1 standard is sequential multi-point fuel injection (SFI).

Unlike conventional multi-point fuel injection systems that deliver fuel continuously or to paired injectors at the same time, sequential fuel injection can deliver fuel precisely when needed by each cylinder. With less than optimum fuel injection timing, fuel puddling and intake-manifold wall wetting can occur, both of which hinder complete combustion. Use of sequential-fuel-injection systems help especially in reducing cold start emissions when fuel puddling and wall wetting are more likely to occur and emissions are highest.

Motorcycle manufacturers are already beginning to use sequential fuel injection (SFI). Of the 97 motorcycle engine families certified for sale in California this year, 7 employ SFI systems. We anticipate increased applications of this or similar fuel injection systems to achieve the more precise fuel delivery needed to help meet the Tier-1 and Tier-2 standards.

Engine Modifications

Emission performance can also be improved by reducing crevice volumes in the combustion chamber. Unburned fuel can be trapped momentarily in crevice volumes before being subsequently released. Since trapped and re-released fuel can increase engine-out emissions, the elimination of crevice volumes would be beneficial to emission performance. To reduce crevice volumes, manufacturers can evaluate the feasibility of designing engines with pistons that have reduced, top "land heights" (the distance between the top of the piston and the first ring).

Lubrication oil which leaks into the combustion chamber also has a detrimental effect on emission performance since the heavier hydrocarbons in oil do not oxidize as readily as those in gasoline and some components in lubricating oil may tend to foul the catalyst and reduce its effectiveness. Also, oil in the combustion chamber may trap HC and later release the HC unburned. To reduce oil consumption, manufacturers can tighten the tolerances and improve the surface finish on cylinders and pistons, piston ring design and materials, and exhaust valve stem seals to prevent excessive leakage of lubricating oil into the combustion chamber.

Increasing valve overlap is another engine modification that can help reduce emissions. This technique helps reduce NOx generation in the combustion chamber by essentially providing passive exhaust gas recirculation (EGR). When the engine is undergoing its pumping cycle, small amounts of combusted gases flow past the intake valve at the start of the intake cycle. This creates what is essentially a passive EGR flow, which is then either drawn back into the cylinder or into another cylinder through the intake manifold during the intake stroke. These combusted gases, when combined with the fresh air/fuel mixture in the cylinder, help reduce peak combustion temperatures and NOx levels. This technique can be effected by making changes to cam timing and intake manifold design to optimize NOx reduction while minimizing impacts to HC emissions.

Current State of Emission Controls

Secondary pulse-air injection and engine modifications already play important parts in reducing emission levels; we expect increased uses of these techniques to help meet the Tier-1 standard. Direct evidence of the extent these technologies can help manufacturers meet the Tier-1 standard can be found in the ARB on-road motorcycle certification database. This database is comprised of publicly-available certification emission levels and confidential data reported by the manufacturers pursuant to existing requirements.

From ARB's certification data, we find that 43 of 87 (49%) Class III engine families certified for Model Year 1998 already had HC levels ranging from 0.23 to 0.89 g/km. Our discussions with manufacturers indicate that typical NOx levels range from about 0.5 to 0.7 g/km. Therefore, these 43 engine families could be certified for HC+NOx levels at about 0.9 to 1.6 g/km (using the higher 0.7 g/km value), primarily by using engine modifications and secondary pulse-air injection. Even at the 1.6 g/km level, the certification data show that it is not necessary for widespread applications of advanced, high-efficiency, two-way or three-way catalysts to meet staff's proposed 1.4 g/km HC+NOx Tier-1 limit (i.e., high-efficiency catalysts are generally not needed to achieve a 13% reduction in emissions, which lowering emissions from 1.6 g/km to 1.4 g/km would require).

Table V-1 shows the breakdown of technologies used by the manufacturers of the 43 engine families noted previously. As Table V-1 demonstrates, only 2 engine families using low-efficiency, three-way catalysts for certification at or near ARB staff's proposed Tier-1 limit. The remaining 41 engine families certify at or near staff's proposal using simpler, less costly engine modifications and secondary pulse-air injection; only five of these employ a two-way catalyst. More importantly, Table V-1 shows that the 43 engine families represent approximately 60% of the 1998 market. Thus, significantly more than half the current number of new motorcycles sold in the State already meet or will likely meet the Tier-1 proposal with relatively simple engine modifications and secondary pulse-air injection.

Table V-1. Breakdown of HC Certification Levels by Technology and Market Share

Certified HC g/km	Total Number Engine Families	Market Share of Class III Sales (% by units)	Number of Engine Families Using Specified Technology			
			Engine Modifications	Pulse Air Injection	2-Way Ox-Cat	3-Way Cat.
0.23 to 0.5	10	12%	4	6	2	0
0.51 to 0.7	16	15%	10	7	2	0
0.71 to 0.89	17	33%	14	2	2	2
Total	43	60%	28	15	6	2

Notes: (1) "Number of Engine Families Using Specified Technology" columns do not add up to "Total Number of Engine Families" column due to overlapping use of different technologies (e.g., engine that uses modifications, pulse-air, and 2-way ox-cat is counted three times, one for each column)
 (2) "Engine Modifications" include all forms of fuel injection, electronic control modules, etc.

Source: 1998 ARB On-Road Motorcycle Certification Database

The manufacturers' ability to meet the proposed Tier-1 standard of 1.4 g/km HC+NOx using optimized versions of currently available, non-catalyst technologies is further documented by information obtained from the Motorcycle Industry Council. According to the MIC, "the best non-catalyst engine families can meet a sales-weighted HC+NOx standard of 1.3 g/km" (1.0 g/km plus a 30% compliance margin to account for variabilities due to manufacturing, testing, supplied parts, etc.; note that MIC reported 0.9 g/km, which appears to be mathematically incorrect). [emphasis in original] (MIC, October 1998) Therefore, taking into account the more difficult-to-control engine families, the staff's proposed Tier-1 standard of 1.4 g/km HC+NOx appears to be reasonably achievable by the industry without the widespread use of catalysts.

C. Meeting the Tier-2 Standard: Using Engine Systems and Catalytic Converters

According to the MIC, "with further refinement of fuel metering and air injection, a more stringent level (beyond Tier-1) of 1.2 g/km HC+NOx is achievable for full-range manufacturers...without the widespread use of catalysts" (i.e., 0.9 g/km HC+NOx plus a 30% compliance margin; note that MIC reported 0.8 g/km, which appears to be mathematically incorrect). (MIC, October 1998) To achieve the Tier-2 standard from this level, manufacturers would need to reduce their corporate average emissions to approximately 0.6 g/km HC+NOx (accounting for a 30% compliance margin). Decreasing average emissions from 0.9 to 0.6 g/km HC+NOx requires an average reduction of about 33% in HC+NOx. This reduction is well within the capabilities of existing three-way catalytic converters, which in current motorcycles have been reported as achieving a 60 to 85% reduction in HC and NOx. (BMW, April 1998; MBNet, August 1998) Due to the high emission reduction capability of three-way catalysts, we expect manufacturers to apply this technology only to the extent necessary and will therefore be able to offer a range of non-catalyst and catalyst-based motorcycles to consumers in 2008.

To meet the Tier-2 standard for HC+NO_x, manufacturers will likely use more advanced engine modifications and secondary air injection. Specifically, we believe manufacturers will use computer-controlled secondary pulse-air injection (i.e., the injection valve would be connected to a computer-controlled solenoid). In addition to these systems, manufacturers will probably need to use catalytic converters on some motorcycles to meet the Tier-2 standards. There are two types of catalytic converters currently in use: two-way catalysts (which controls only HC and CO) and three-way catalysts (which controls HC, CO, and NO_x). Under the Tier-2 standard, manufacturers will need to minimize levels of both HC and NO_x. Therefore, to the extent catalysts are used, manufacturers will likely use a three-way catalyst in addition to engine modifications and computer-controlled, secondary pulse-air injection.

The following section will discuss methods that manufacturers will likely explore for maximizing the effectiveness of fuel delivery systems and three-way catalysts while minimizing impacts on performance and cost. Many of these technologies have been successfully used in automobiles and will likely be transferred to motorcycle applications.

Technologies for Improving Fuel Control

As discussed previously, improving fuel control and delivery provides emission benefits by helping to reduce engine-out emissions and minimizing the exhaust variability which the catalytic converter experiences. One method for improving fuel control is to provide enhanced feedback to the computer-controlled fuel injection system through the use of heated oxygen sensors. Heated oxygen sensors (HO₂S) are located in the exhaust manifold to monitor the amount of oxygen in the exhaust stream and provide feedback to the electronic control module (ECM). These sensors allow the fuel control system to maintain a tighter band around the stoichiometric A/F ratio than conventional O₂ sensors. In this way, HO₂S assist vehicles in achieving precise control of the A/F ratio and thereby enhance the overall emissions performance of the engine.

In order to further improve fuel control, some motorcycles with electronic controls may utilize software algorithms to perform individual cylinder fuel control. While dual oxygen sensor systems are capable of maintaining A/F ratios within a narrow range, some manufacturers may desire even more precise control to meet their performance needs. On typical applications, fuel control is modified whenever the O₂S determines that the combined A/F of all cylinders in the engine or engine bank is “too far” from stoichiometric. The needed fuel modifications (i.e., inject more or less fuel) are then applied to all cylinders simultaneously. Although this fuel control method will maintain the “bulk” A/F for the entire engine or engine bank around stoichiometric, it would not be capable of correcting for individual cylinder A/F deviations that can result from differences in manufacturing tolerances, wear of injectors, or other factors.

With individual cylinder fuel control, A/F variation among cylinders will be diminished, thereby further improving the effectiveness of the emission controls. By modeling the behavior of the exhaust gases in the exhaust manifold and using software algorithms to predict individual cylinder A/F, a feedback fuel control system for individual cylinders can be developed. Except for

the replacement of the conventional front O₂S with an HO₂S sensor and a more powerful engine control computer, no additional hardware is needed in order to achieve individual cylinder fuel control. Software changes and the use of mathematical models of exhaust gas mixing behavior are required to perform this operation. Sensors and the improved software needed to achieve individual cylinder fuel control are currently being used by at least 2 automobile manufacturers on 1998 model year vehicles; because these components are relatively small in size, we believe there is potential to apply this technology to on-road motorcycles.

In order to maintain good driveability, responsive performance, and optimum emission control, fluctuations of the A/F must remain small under all driving conditions including transient operation. Virtually all current fuel systems in automobiles incorporate an adaptive fuel control system that automatically adjusts the system for component wear, varying environmental conditions, varying fuel composition, etc., to more closely maintain proper fuel control under various operating conditions. For some fuel control systems today, this adaptation process affects only steady-state operating conditions (i.e., constant or slowly changing throttle conditions). However, most vehicles are now being introduced with adaptation during "transient" conditions (e.g., rapidly changing throttle, purging of the evaporative system).

Accurate fuel control during transient driving conditions has traditionally been difficult because of the inaccuracies in predicting the air and fuel flow under rapidly changing throttle conditions. Because of air and fuel dynamics (fuel evaporation in the intake manifold and air flow behavior) and the time delay between the air flow measurement and the injection of the calculated fuel mass, temporarily lean A/F ratios can occur during transient driving conditions that can cause engine hesitation, poor driveability and primarily an increase in NO_x emissions. However, by utilizing fuel and air mass modeling, vehicles with adaptive transient fuel control are more capable of maintaining accurate, precise fuel control under all operating conditions. Virtually all cars sold in California will incorporate adaptive transient fuel control software; motorcycles with computer controlled fuel injection can also benefit from this technique at a low cost.

Technologies for Improving Catalyst Performance

Catalyst Enhancements. Three-way catalytic converters traditionally utilize rhodium and platinum as the catalytic material to control the emissions of all three major pollutants (hydrocarbons (HC), CO, NO_x). Although this type of catalyst is very effective at converting exhaust pollutants, rhodium, which is primarily used to convert NO_x, tends to thermally deteriorate at temperatures significantly lower than platinum. Recent advances in palladium and tri-metal (i.e., palladium-platinum-rhodium) catalyst technology, however, have improved both the light-off performance (light-off is defined as the catalyst bed temperature where pollutant conversion reaches 50% efficiency) (Mazda, 1998; Degussa, 1998) and high temperature durability over previous catalysts (SAE 980042, 980672). In addition, other refinements to catalyst technology, such as higher cell density substrates and adding a second layer of catalyst washcoat to the substrate (dual-layered washcoats), have further improved catalyst performance from just a year ago.

Typical cell densities for conventional catalysts used in motorcycles are less than 300 cells per square inch (cpsi). To meet the Tier-2 standard, we expect manufacturers to use catalysts with cell densities of 300 to 400 cpsi. If catalyst volume is maintained at the same level (we assume volumes of up to 60% of engine displacement), using a higher density catalyst effectively increases the amount of surface area available for reacting with pollutants. Catalyst manufacturers have been able to increase cell density by using thinner walls between each cell without increasing thermal mass (and detrimentally affecting catalyst light-off) or sacrificing durability and performance. (SAE, 1998; SAE 980670, 980420)

In addition to increasing catalyst volume and cell density, staff believes that increased catalyst loading and improved catalyst washcoats will help manufacturers meet the Tier-2 standard. In general, increased precious metal loading (up to a certain point) will reduce exhaust emissions because it increases the opportunities for pollutants to be converted to harmless constituents. The extent to which precious metal loading is increased will be dependent upon the precious metals used and other catalyst design parameters. We believe recent developments in palladium/rhodium catalysts are very promising since rhodium is very efficient at converting NO_x, and catalyst suppliers have been investigating methods to increase the amount of rhodium in catalysts for improved NO_x conversion. (Mazda, 1998; Degussa, 1998; SAE 980666, 980667)

Double layer technologies allow optimization of each individual precious metal used in the washcoat. This technology can provide reduction of undesired metal-metal or metal-base oxide interactions while allowing desirable interactions. Industry studies have shown that durability and pollutant conversion efficiencies are enhanced with double layer washcoats. These recent improvements in catalysts can help manufacturers meet the Tier-2 standard at reduced cost relative to older three-way catalysts.

There is some indication that palladium/rhodium catalysts are thermally more sensitive than other catalyst technologies (i.e., palladium-only) and would deteriorate more noticeably with mileage. However, based on discussions with some suppliers and ARB test results on automobiles using these catalysts, we believe that improved washcoat designs (e.g., double-layer washcoats) will reduce thermal deterioration on these catalysts.

New washcoat formulations are now thermally stable up to 1050 °C. This is a significant improvement from conventional washcoats, which are stable only up to about 900 °C. With the improvements in light-off capability, catalysts may not need to be placed as close to the engine as previously thought. However, if placement closer to the engine is required for better emission performance, improved catalysts based on the enhancements described above would be more capable of surviving the higher temperature environment without deteriorating. The improved resistance to thermal degradation will allow closer placement to the engines where feasible, thereby providing more heat to the catalyst and allowing them to become effective quickly.

Improved Catalyst Light-off with Computer-Controlled Secondary Air Injection (SAI) and Retarded Spark Timing. It is well established that a warmed-up catalyst is very effective at converting exhaust pollutants. Recent tests on advanced catalyst systems in automobiles have shown that over 90% of emissions during the Federal Test Procedure (FTP) are now emitted during the first two minutes of testing after engine start up. Similarly, the highest emissions from a motorcycle occur shortly after start up. Although improvements in catalyst technology have helped reduce catalyst light-off times, there are several methods to provide additional heat to the catalyst. Retarding the ignition spark timing and computer-controlled, secondary air injection have been shown to increase the heat provided to the catalyst, thereby improving its cold-start effectiveness. Several motorcycle manufacturers are investigating these techniques for application to their vehicles.

Catalyst System Changes. In addition to using computer-controlled SAI and retarded spark timing to increase the heat provided to the catalyst, some vehicles may employ warm-up, pre-catalysts to reduce the size of their main catalytic converters. Palladium-only warm-up catalysts (also known as “pipe catalysts” or “Hot Tubes”) using ceramic or metallic substrates may be added to further decrease warm-up times and improve emission performance. Although metallic substrates are usually more expensive than ceramic substrates, some manufacturers and suppliers believe metallic substrates may require less precious metal loading than ceramic substrates due to the reduced light-off times they provide.

While nearly all catalysts in use today are applied on a honeycomb substrate, there are new developments that indicate potential benefits from using other substrate structures such as an open-cell foam. Ultramet is developing a silicon carbide open-cell foam substrate for use in catalytic converters (“UltraCat”). Its reported advantages include a radial flow design (for increased contact with the exhaust gas), fast-lightoff capability, uniform heating throughout the substrate, high resistance to thermal degradation, and lower pressure drop (for minimal reduction in horsepower). (SAE 980669) While more work needs to be done to commercialize this technology, our discussions with Ultramet indicate that this system has potential for use in motorcycles, which may be realized over the next ten years before the Tier-2 standard becomes effective.

Heat-Optimized Exhaust Pipe. Improving insulation of the exhaust system is another method of furnishing heat to the catalyst. Similar to close-coupled catalysts, the principle behind insulating the exhaust system is to conserve the heat generated in the engine for aiding catalyst warm-up. Through the use of laminated thin-wall exhaust pipes, less heat will be lost in the exhaust system, enabling quicker catalyst light-off. (SAE 980937) As an added benefit, the use of insulated exhaust pipes will also reduce exhaust noise. Increasing numbers of manufacturers are expected to utilize air-gap exhaust manifolds (i.e., manifolds with metal inner and outer walls and an insulating layer of air sandwiched between them) for further heat conservation.

Engine Calibration Techniques

Besides the hardware modifications described above, motorcycle manufacturers may borrow from other current automobile techniques. These include using engine calibration changes such as a brief period of substantial ignition retard, increased cold idling speed, and leaner air-fuel mixtures to quickly provide heat to a catalyst after cold-starts. Only software modifications are required for an engine which already uses a computer to control the fuel delivery and other engine systems. For these engines, calibration modifications provide manufacturers with an inexpensive method to quickly achieve light-off of catalytic converters. When combined with pre-catalysts, computer-controlled SAI, and the other heat conservation techniques described above, engine calibration techniques may be very effective at providing the required heat to the catalyst for achieving the Tier-2 standard. These techniques are currently in use on most low emission vehicle (LEV) automobiles and may have applications in on-road motorcycles.

D. Safety

The primary safety issue regarding the proposed standards is the safety of the rider in close proximity to hot exhaust pipes and the catalytic converter. Since the Tier-2 standard will likely result in the use of catalytic converters on some motorcycles, protecting the rider from excessive heat is a concern for manufacturers. Reducing the temperature of exhaust gases is not desirable, because doing so will reduce the effectiveness of the catalyst. Fortunately, most solutions that address this concern use relatively uncomplicated shielding approaches. Examples include exterior pipe covers that slip over existing pipes, shielded foot rests, and similar components. (Harley-Davidson 1998 Parts Catalog; U.S. Patent#s 4,023,821; 4,699,232; 4,955,193) Motorcycle manufacturers can also take other approaches. Some manufacturers currently place the catalytic converter under the motorbike to keep it away from the rider. Other manufacturers will likely use double-pipe exhaust systems that aim to reduce heat loss (so the exhaust gases remain hot prior to reaching the catalyst) while staying cooler on the exterior. (Japan Patent# 08082214) Based on these approaches, we conclude that problems with heat management and rider safety are not insurmountable within the nine-year timeframe provided.

VI.

COMMERCIAL FEASIBILITY AND ECONOMIC IMPACTS OF PROPOSED STANDARDS

We conducted an extensive impacts analysis to evaluate the commercial feasibility of the proposed standards and their potential economic impacts. To meet the requirements of applicable statutes, we have organized this section to summarize the economic impacts; describe the legal requirements for this analysis; identify businesses potentially affected; discuss the projected economic impacts on California businesses, consumers, and State or local agencies; and compare the cost-effectiveness of the proposed standards with other ARB-adopted measures.

A. Summary of Economic Impacts

Overall, we do not expect the proposed regulation to impose a significant cost burden on motorcycle manufacturers. We expect the proposed two-tier standards will primarily impact six major manufacturers (BMW, Harley-Davidson, Honda, Kawasaki, Suzuki, and Yamaha), all headquartered outside of California. Some manufacturers, however, may have small operations in California. There are also very small, custom motorcycle builders that have total production runs on the order of 100 units per year; at least one of these custom builders is located in California.

We estimate the average annual costs of the proposed regulation to be around \$1.4 million in 2004 and \$3.2 million in 2008. We expect these costs to be passed on fully to motorcycle purchasers, resulting in a 0.6 percent increase in 2004 in the average retail price of a motorcycle, relative to the 1998 average price of \$7,600 per motorcycle. The average retail price of a 1998 motorcycle is expected to increase by 1.3 percent upon full implementation of the Tier-2 standard in 2008. A price increase of this magnitude is generally not expected to significantly dampen the demand for motorcycles. As a result, we conclude that the proposed regulation will impose no noticeable adverse impacts on California competitiveness, employment, and business status. Furthermore, the proposed regulation is not a major regulation under Health and Safety Code section 57005 because the regulation's impacts on California businesses do not exceed ten million dollars in a single year.

B. Legal Requirements

Section 11346.3 of the Government Code requires State agencies to assess the potential for adverse economic impacts on California business enterprises and individuals when proposing to adopt or amend any administrative regulation. The assessment shall include a consideration of the impact of the proposed regulation on California jobs; business expansion, elimination, or creation; and the ability of California businesses to compete.

Also, section 11346.5 of the Government Code requires State agencies to estimate the cost or savings to any State or local agency and school district in accordance with instructions adopted by the Department of Finance. The estimate shall include any nondiscretionary cost or savings to local agencies and the cost or savings in federal funding to the State.

Health and Safety Code section 57005 requires the ARB to perform a cost analysis of alternatives to the proposed regulation under specified circumstances. The analysis is required when the proposed regulation is a major regulation, which is defined as a regulation that will have a potential cost to California business enterprises in an amount exceeding ten million dollars in any single year.

C. Businesses Affected

Any business involved in manufacturing and use of on-road motorcycles would potentially be affected by the proposed regulation. Also potentially affected are businesses which supply parts to these manufacturers and companies which sell or service motorcycles in California. The focus of this analysis, however, will be on the on-road motorcycle manufacturers because these businesses would be directly affected by the proposed regulation. These manufacturers are classified in the industry identified by Standard Industrial Classification (SIC) 3750 and new North American Industry Classification (NAICS) 336991.

The motorcycle industry consists primarily of six major manufacturers worldwide. These manufacturers control over 95 percent of the market share in California; the balance is controlled by a number of small-volume manufacturers. None of the major manufacturers is located in California, although some may have limited operations in California. Table VI.1 provides a list of the major companies in the motorcycle industry along with their respective 1996 U.S. market shares.

Table VI-1. Major Manufacturers in the Motorcycle Industry

Company	1996 Market Share
Honda	29.5%
Harley-Davidson	25.4%
Kawasaki	14.3%
Yamaha	13.4%
Suzuki	13.4%
BMW	1.5%
All Others	2.5%

Source: 1997 Motorcycle Statistical Annual, Motorcycle Industry Council Inc., Irvine, California, January 1997.

D. Potential Impacts on California Businesses

Manufacturers

We expect the proposed standards to impose additional costs on manufacturers of on-road motorcycles. A detailed analysis of these costs is provided in the section J of this chapter (Cost-Effectiveness). The cost analysis shows that the proposed regulation will increase average annual costs of manufacturing motorcycles by about \$1.4 million when the Tier-1 standard becomes effective in 2004 and by \$3.2 million when the Tier-2 standards become effective in 2008. The bulk of the cost increase will be born by a small number of major manufacturers. Under the staff's proposal, small-volume manufacturers will be subject only to the Tier-1 standard. These small-volume manufacturers are unlikely to spend any of their own resources on developing new technology; they are more likely to rely on their suppliers for the technology to comply with the regulation. Costs incurred by small-volume manufacturers will principally be spent on engine calibration and compliance assurance.

Small-volume manufacturers usually tend to fill special niches in the market, in which price may not be the primary factor to induce a product sale. Factors such as a product's unique features and superior service may be more important to customers than the product price. In such a market, because consumers are less sensitive to price changes, manufacturers are also likely to pass on the cost increase to consumers. Major manufacturers are also likely to pass on the cost increase to consumers in the long run if they are unable to lower their production costs. However, because of the long lead times involved (5 years for Tier-1, 9 years for Tier-2), it is more likely that manufacturers would be able to make the required adjustments cost-effectively. As a result, we do not expect the regulation to have a noticeable adverse impact on affected major and small-volume manufacturers.

Aftermarket Parts Manufacturers and Distributors

There are a number of manufacturers and distributors that specialize in aftermarket parts for on-road motorcycles, some of which are located in California. According to the MIC 1997 Statistical Annual, the on-road aftermarket parts and accessories industry comprises a significant fraction of overall motorcycle-related sales. Companies in this sector manufacture aftermarket engine parts, electronic control modules, exhaust systems, and other parts for both do-it-yourself (DIY) and original equipment manufacturer (OEM) applications; the fraction of aftermarket sales comprising DIY versus OEM supply is unknown to staff.

Because of the technologies we expect will be used to comply with the proposed standards, the staff proposal may impact the aftermarket manufacturers and distributors in two ways. First, we anticipate that the original equipment manufacturers (OEM) will use more tamper-resistant or more durable designs to maintain reduced emissions for the 30,000 km durability requirement. Tamper-resistant or more durable designs may reduce demand for aftermarket parts intended to be added by the consumer, thereby potentially decreasing

aftermarket manufacturer sales. A second potential impact may result as aftermarket parts manufacturers incur costs when designing new parts that will comply with the staff's proposed standards.

To minimize these impacts, we have proposed the Tier-2 standard at a level which we believe will address tampering by consumers (see Chapter IV). As discussed in section J of this chapter, we believe the proposed 0.8 g/km HC+NO_x Tier-2 standard will result in catalysts being applied to a portion of the market, while the remaining portion will comply primarily with engine modifications and secondary pulse-air injection. Because OE manufacturers will be able to sell both catalyst and non-catalyst-based motorcycles, aftermarket parts manufacturers will still be able to produce parts for both types of motorcycles. Moreover, these manufacturers will need to design and produce catalyst-based parts for only a portion of the market, rather than all motorcycles. Thus, the proposed Tier-2 standard should help to minimize the costs incurred by aftermarket parts manufacturers and distributors.

Retailers

We do not expect retailers to be significantly affected by the proposed regulation. Most motorcycle manufacturers and distributors sell their products through franchised and non-franchised outlets. Franchised outlets are engaged in selling new motorcycles, scooters, or all-terrain vehicles, while non-franchised outlets specialize in selling motorcycle-related parts, accessories, riding apparel, used vehicles or service. (MIC 1997 Statistical Annual, p.8) In 1997, California had 1,147 motorcycle retail outlets, of which 293 were franchised outlets and 854 were non-franchised outlets. (MIC 1997 Statistical Annual, p.7)

These outlets are not affected directly by the proposed regulation. However, they may be impacted indirectly by the regulation if the increased price of new motorcycles reduces sales volume, thereby resulting in a reduction of revenues for franchised outlets. Non-franchised outlets may also experience a reduction in their revenues if the regulation results in improved durability of new motorcycles, which would reduce the need for services and aftermarket parts. These indirect impacts are unlikely to be significant because the regulation is expected to cause about an overall 1.3 percent increase in the \$7,600 price of an average new 1998 motorcycle upon full implementation in 2008. (MIC 1997 Statistical Annual, p.1) Even under a worst-case scenario where all regulatory costs are spread over California sales instead of national sales (i.e., all manufacturers produce a separate California and 49-state motorcycle), we expect the regulation to increase the average motorcycle price by only 2.6 percent. A price increase of this magnitude is not expected to dampen the demand for motorcycles significantly; indeed, it is generally recognized that price increases up to 10 percent would not significantly reduce sales. (ACEM at 48).

E. Potential Impacts on Business Competitiveness

For various reasons, the proposed regulation should have no significant impacts on the ability of California manufacturers to compete with manufacturers of similar products in other states. First, all manufacturers that produce motorcycles for sale in California are subject to the proposed regulation regardless of their location. Thus, manufacturers in Japan, Germany, or in the U.S. all have to meet the same requirements that a California manufacturer would need to meet. Moreover, none of these major manufacturers is located in California, although they may have some operations in California. Finally, we expect the proposed standards to cause a negligible increase in the retail price of the average motorcycle, which is unlikely to dampen the demand for motorcycles in California.

F. Potential Impacts on Employment

California companies do not manufacture motorcycles and account for only a small share of manufacturing employment for aftermarket motorcycle parts. According to the U.S. Department of Commerce, California employment in the industry (SIC 3750), which includes establishments primarily involved in manufacturing motorcycles, bicycles, tricycles, and similar equipment and parts, was slightly over 2,300 in 1995 or about 0.1 percent of the total manufacturing jobs in California. These employees working in 131 establishments generated approximately \$64 million in payroll. Only five establishments had between 100 to 500 employees; the remainder had less than 100 employees each. The proposed regulation is unlikely to cause a noticeable change in employment for these manufacturers because they are likely to pass on the bulk of the cost increase to consumers. A few manufacturers engaged in manufacturing emissions control and fuel management components may actually hire more employees if they experience an increase in demand for their products.

According to the Motorcycle Industry Council, there were 1,141 motorcycle retail outlets in California, employing an estimated 7,600 employees with an annual payroll of about \$167 million in 1997. (MIC 1997 Statistical Annual, p. 7). From earlier discussions, we would not expect these employees to be adversely affected because a small price increase is unlikely to dampen demand for motorcycles in California. Therefore, the staff's proposal should have no noticeable impact on California employment because of the marginal contribution of the industry to the California economy.

G. Potential Impact on Business Creation, Elimination, or Expansion

According to the MIC, the California motorcycle industry sold about 37,500 motorcycles with a retail value of approximately \$283 million in 1996. (MIC 1997 Statistical Annual, p.6). The industry's contribution to the California economy was estimated to be around \$950 million, which includes retail sales of motorcycles (new and used); parts and accessories; dealer servicing; product advertising; vehicle financing charges; insurance premiums; dealer personnel salaries; state sales and dealer personal income taxes; and vehicle registration fees. (MIC 1997 Statistical

Annual, pp.7-8). Although this is a sizable industry, its contribution to the one trillion dollar California economy is relatively small. Moreover, the direct impact of the proposed regulation would be on that part of the industry which is engaged in the manufacturing of motorcycles. These manufacturers are all located outside of California. A few emissions control and fuel management component manufacturers, however, are located in California. These manufacturers may actually benefit from the proposed regulation if motorcycle manufacturers purchase more of their products. This would, in turn, result in an expansion of those businesses.

As discussed earlier, we do not expect the proposed regulation to have a noticeable impact on motorcycle retail outlets. We estimated the proposal's cost impact to be about a 1.3 percent increase in the average retail price of a motorcycle (relative to 1998), which is not expected to significantly dampen the demand for motorcycles. As a result, the proposed regulation should not cause a noticeable change in the status of California businesses.

H. Potential Impacts on Consumers

The potential impact of the proposed regulation on retail prices of motorcycles depends on the ability of manufacturers to pass on the cost increase to consumers. Assuming that manufacturers are able to pass on the entire costs of compliance to motorcycle purchasers, staff estimate that the average price of a motorcycle (relative to 1998) would increase by about \$44 per bike when the Tier-1 standard takes effect in 2004 and by about \$97 per bike when the Tier-2 standard take effect in 2008. This represents an average increase of about 1.3 percent in the typical motorcycle retail price of about \$7,600. (MIC 1997 Statistical Annual, p.7). A price increase of this magnitude is not expected to have a significant impact on the demand for motorcycles in California. (ACEM, p.48).

The price increase may actually be negligible compared to the performance advantages that new motorcycles will offer to consumers. Improved engine durability due to engine modifications employed to meet the standards would potentially reduce the need for parts and services, resulting in cost savings to consumers. Additional savings may also occur due to the improvement in fuel-delivery systems (i.e., fuel injection).

I. Economic Impacts on California State or Local Agencies

We do not expect the staff's proposal to have any impact on State or local agencies because no public agencies in the State are involved in the manufacturer or sale of affected on-road motorcycles. While various police departments and the California Highway Patrol do purchase motorcycles for official use, they would not experience any impacts because Vehicle Code section 27156.2 exempts vehicles used by peace officers from the requirement for pollution control devices. Thus, the regulation will not adversely impact State or local agencies.

J. Cost-Effectiveness of the Proposed Standards

Methodology and Assumptions

We began our analysis by defining the systems and technologies likely to be used by manufacturers to meet the proposed Tier-1 and Tier-2 limits. To do this, we held discussions with engineers from the motorcycle manufacturers and emission control suppliers. We also reviewed the literature and ARB's motorcycle certification database to determine what technologies are in place in current motorbikes. Finally, we relied on ARB's more than 20 years experience with automotive and motorcycle emission controls and our best engineering judgment to ensure that the assumed technologies and cost figures are realistic. From this process, we determined the most likely emission control technologies that would be needed to meet the proposed model year 2004 and 2008 requirements.

We should note that some manufacturers do not entirely agree with the technologies or combination of technologies we determined will help meet the proposed limits. However, our experience with motor vehicle manufacturers generally shows that industry tends to overestimate the level of technology and amount of hardware needed to meet standards proposed by ARB in the past. (ARB, 1998c). During this rulemaking, our technical discussions with motorcycle manufacturers indicated that these companies may also be overestimating the technologies needed to meet our proposal. While it is true that some individual engine families may be more difficult to control than others, our technical analysis shows that engine families in general are similar enough to enable reasonably accurate predictions as to what technologies will be needed. Therefore, the cost estimates shown in this section represent our best engineering judgment and apply to typical motorcycles that need to be modified to meet the standards; on an individual basis, manufacturers may experience higher or lower costs than those shown here.

In general, the cost to manufacturers for the individual components in each of the systems currently under development are fairly well established. Once we defined and determined the emission systems and their costs, our assessment of non-hardware fixed and variable costs to manufacturers becomes less clear since these costs are closely guarded by individual manufacturers; such costs may vary significantly within the industry. Besides the cost of hardware, the ARB staff considered additional variable costs including costs of assembly, shipping and warranty. Further, fixed support costs (research, legal and administrative), investment recovery (machinery and equipment to manufacture the parts, assembly plant changes, vehicle development, and costs of capital recovery) and dealer costs (dealership operating costs and costs of capital recovery) were also included in our analysis. Our estimates of these costs were based on our extensive experience with motor vehicle regulations and confidential discussions with manufacturers and suppliers.

Analysis

In performing this cost study, we departed from industry practice of assigning a fixed percentage of the manufacturer's variable cost to cover indirect costs (which include research, legal, and administrative costs). Rather, we analyzed where such long term costs would actually occur, at both the manufacturer and dealer levels. The reference vehicles for this cost study are model year 1998 California motorcycles for which certification data were available to permit a detailed evaluation of the specific technologies used. Our analysis evaluated both subgroups comprising the Class III motorcycle category -- those with engine displacements between 280 and 699 cc, and those with engine displacement of 700 cc and greater.

Tables VI-2 thru VI-7 provide additional information on the cost figures and assumptions used in our analysis, which are discussed in more detail as follows.

Variable Costs

In this section the cost of new parts added, additional assembly operations, any increases in the cost of shipping parts and any new warranty implications are addressed.

Cost of Parts: Proposed 1.4 g/km HC+NO_x Tier-1 standard

The California 1998 on-road motorcycle certification data indicate that the sales-weighted average emissions of class III 1998 motorcycles with engine displacements greater than 700 cc (which constitute most of the class III fleet) is approximately 0.9 g/km HC, well below the current 1.4 g/km HC-only corporate fleet average requirement. Although data regarding NO_x emissions associated with these motorcycles are scarce, ARB's limited in-use testing data and confidential information provided to the ARB by some motorcycle manufacturers indicate that NO_x emissions are typically very low relative to HC emissions for motorcycles. Therefore, we estimate that only some harder-to-control motorcycles would require changing from a carbureted system to a computer-controlled fuel injection system in order to meet the proposed standard.

For motorcycles which need to be fitted with a fuel injection system, we accounted for the costs associated with adding a control computer, fuel injectors, fuel pump, pressure regulator, air-flow sensor, crank position sensor and throttle position sensor. From these added costs, we subtracted the savings that would result from not installing a carburetor system. Motorcycles equipped with fuel injection systems are less likely to be tampered with and, consequently, yield better emission performance relative to carbureted systems.

Other motorcycles in the certification database appear likely to meet the proposed standards with only minor modifications to existing systems, with virtually no additional hardware. To be conservative, we assumed nearly all motorcycles would employ, at a minimum, a simple pulse-air injection system, which involves a fresh air hose to the exhaust with a check-valve to prevent backflow.

Cost of Parts: Proposed 0.8 g/km HC+NO_x Tier-2 standard

As noted previously, the 0.8 g/km HC+NO_x Tier-2 proposed standard is based on our expectation that about 40% of the market would not need catalytic converters to meet the Tier-2 standard (i.e., they would essentially remain at 1.0 to 1.4 g/km HC+NO_x levels); the remaining portion of the market would then use catalytic converters and other modifications to achieve emissions down to 0.4 g/km HC+NO_x levels or even lower. We expect the overall result will achieve the 0.8 g/km HC+NO_x level on a corporate average basis. This is important to note, since not all on-road motorcycles are expected to incur the cost for parts needed to meet the 0.8 g/km standard.

For those motorcycles that will need equipment beyond the Tier-1 level, our discussions with motorcycle manufacturers, component suppliers, and other industry experts indicate that such motorcycles would require either an oxidation catalyst or, in some cases, a three-way catalyst and a fuel-injection system to meet a 0.8 g/km HC+NO_x standard. These motorcycles would also need to be equipped with heated oxygen sensor(s) to provide feedback to the fuel-injection system. These sensors would be needed to maintain engine-out emissions close to stoichiometric to maximize emission performance of the three-way catalysts. Some vehicles may also require high cell density catalysts to meet emission targets and allow for head-room. Typically, catalysts that would be used on motorcycles are expected to be metallic catalysts (although some catalyst manufacturers are pursuing ceramic catalysts for motorcycles) and are estimated to cost approximately \$100 per liter. Also, we expect motorcycles meeting this standard to use a more sophisticated, programmed pulse-air system, in which air flow to the exhaust system is controlled by a solenoid valve linked to the engine computer.

Table VI-2 provides detailed breakdowns of component usage and costs for the emission control systems needed to meet the staff's proposal. The costs were calculated by projecting the specified components over the portion of the new motorcycle fleet which we believe would need such equipment. Since the Tier-1 standard is based primarily on non-catalyst technologies, Table VI-2 shows the added costs for a fuel injection system, engine modifications, and simple pulse-air injection; the cost savings from not installing a carburetor system are also shown as negative costs. For the Tier-2 standard, we added the costs to equip half of the new motorcycle fleet with heated oxygen sensors; fuel injection; three-way catalysts; engine modifications; and computer-controlled, pulse-air injection. We also subtracted the cost savings from not installing two-way catalysts and carburetors, as shown.

Table VI-2. Component Costs to Comply with Staff Proposal (Relative to 1998 Models)

Tier-1: 1.4 g/km HC+NOx	Engine Displacement 280 to 699 cc				Engine Displacement ≥ 700 cc			
	Estimated Cost (\$) [A]	1998 Use Rate (%) [B]	Use Rate to meet Std. (%) [C]	Compnt Cost (\$) [D]	Estimated Cost (\$) [E]	1998 Use Rate (%) [F]	Use Rate to meet Std. (%) [G]	Compnt Cost (\$) [H]
Heated O2 Sensor	12	0	0	0	12	3	3	0
Fuel Injection System (1)	150	0	28	42	150	15	44	43.50
Carburetor(s)	108	100	72	-30.24	108	85	59	-28.08
Oxidation Catalyst	20	13	13	0	25	28	28	0
Three-Way Catalyst(s)	27	0	0	0	27	3	3	0
Engine Modifications (2)	0	24	24	0	10	29	100	7.10
Pulse-Air (3)	8	75	100	2	8	33	100	5.36
Total Incremental Component Cost, \$				13.76	27.88			

Tier-2: 0.8 g/km HC+NOx	Engine Displacement 280 to 699 cc				Engine Displacement ≥ 700 cc			
	Estimated Cost (\$) [A]	1998 Use Rate (%) [B]	Use Rate to meet Std. (%) [C]	Compnt. Cost (\$) [D]	Estimated Cost (\$) [E]	1998 Use Rate (%) [F]	Use Rate to meet Std. (%) [G]	Compnt. Cost (\$) [H]
Heated O2S (4)	18	0	100	18	18	3	100	17.46
Fuel Injection System (5)	150	0	60	90.00	150	15	60	67.50
Carburetor(s)	108	100	40	-64.80	108	85	40	-48.60
Oxidation Catalyst	20	13	0	-2.60	25	28	0	-7
Three-Way Catalyst(s) (6)	27	0	60	16.20	53	3	60	30.21
Engine Modifications (7)	0	24	24	0	20	29	100	14.20
Pulse-Air (8)	12	75	100	3	12	33	100	8.04
Total Incremental Component Cost, \$				59.80	81.81			

Notes: Column [D] = [A] x (([B] - [C])/100), Column [H] = [E] x (([F] - [G])/100)

- (1) Fuel injection system cost includes cost of fuel injector(s), ECM, fuel pressure regulator, higher pressure pump, crank-position sensor, air-flow sensor and throttle position sensor
- (2) Engine modifications could include revised piston ring land height, revised head gaskets to reduce crevice volumes, etc.
- (3) This system involves a hose to the exhaust with a check valve to prevent backflow, plus a silencer.
- (4) We assumed half of new motorcycles would use two oxygen sensors (one for each bank), while remainder would use one sensor; estimated cost for each sensor is \$12.
- (5) Fuel injection system cost includes cost of fuel injector(s), ECM, fuel pressure regulator, higher pressure pump, crank-position sensor, air-flow sensor and throttle position sensor
- (6) High cpsi advanced catalyst; we assumed catalyst volume of 40% engine displacement for 280-669cc (sales-wtd avg. 600cc) and 70% engine displacement for >700cc (sales-wtd avg. 1200cc), catalyst cost of \$100/liter.
- (7) Engine modifications could include reduced crevice volumes, changes for greater cylinder mixing, dual spark plugs, etc.
- (8) More sophisticated pulse-air injection where air injection is computer controlled by solenoid valve linked to the ECM.

Cost of Assembly, Shipping, & Warranty

Installation of fuel injection and a pulse air system would require additional assembly time and would result in additional labor costs. We estimated it would take an additional three minutes to install the fuel injection system during production, including the additional sensors, and an additional minute to install the pulse air system. The additional assembly costs were estimated using a labor cost of \$60 per hour.

Those motorcycles equipped with fuel injection system and catalysts would also incur additional shipping costs. The cost was estimated to be approximately \$2.00 for all of the additional components of a fuel injection system and \$1.00 for a catalyst system.

Motorcycles will increasingly use fuel injection strategies to meet the proposed standards. ARB staff believe that motorcycles utilizing fuel injection systems are less prone to warranty problems when compared to today's carbureted systems. We therefore believe fuel injection systems will provide an overall cost savings under this category. Further, manufacturers that use catalysts to meet the standards are not expected to incur any significant additional warranty costs, since currently available catalyst technology has been demonstrated to be durable well beyond the 30,000 km useful life specified for on-road motorcycles.

Support (Fixed) Costs

Support costs affecting the retail price of meeting new emission requirements include research costs, legal coverage for new issues, and administrative increases.

Research Costs

Manufacturers have until 2003 to meet the proposed 1.4 g/km standard and until 2008 to meet the 0.8 g/km standard. Providing a long lead-time permits considerable cost savings for industry. Incorporation of the required changes can take place systematically within the existing new motorcycle development process without incurring redesign to accommodate unplanned revisions due to frequently changing emission requirements.

Despite the cost savings permitted by setting long range standards, allocation of some additional cost to manufacturers for performing advance system development work is justified when engineering new types of technologies. Consequently, we added development costs that include personnel, overhead and other miscellaneous costs for new technologies such as fuel injection systems and advanced three-way catalysts. Allowance was also made for the cost of a fleet of advanced-development motorcycles for use as technology test-beds. Each motorcycle used for advanced-development research was assumed to cost \$40,000. Details of this assessment are shown in Table VI-3. It is common industry practice to assign development costs of new technologies over the entire product line (rather than just the products on which the technology(ies) is used) and to recoup these over a reasonable period of time. Therefore, for the purpose of this study, the costs incurred under this category were distributed over 15,000 vehicles

per year (which is the typical national volume for most major motorcycle manufacturers) for a total of 15 years.

Table VI-3. Estimated Advanced Vehicle Technology Research Costs (1)

Emission Control Technology	Engineering Staff for Technology Development		Engineering Staff Cost (2) (in \$) [C]	Development Motorcycles Cost (3) (in \$) [D]	Additional Equipment (4) (in \$) [E]	Cost per Vehicle (5) (\$/vehicle) [F]
	(person-yrs) [A]	(person-hrs) [B]				
3-way catalyst evaluation	4	8320	499,200	120,000	50,000	2.97
Fuel-injection strategies	4	8320	499,200	120,000	50,000	2.97
Engine modifications	4	8320	499,200	120,000	50,000	3.29
Total						9.23

Notes: [F] = ([C] + [D] + [E]) / (15,000 bikes/yr x 15 yr); [C] = [B] x \$60/hr; [B] = [A] x 8 hr/day x 260 day/yr

- (1) For advance engineering work in contrast to vehicle calibration or certification work
- (2) Development cost includes personnel, overhead and other miscellaneous costs at a total rate of \$60/hr.
- (3) Cost distributed over 15,000 vehicles per year for total of 15 years.
- (4) Cost added to cover new test equipment, prototype parts, and emissions testing costs.

Legal and Administrative Costs

The technologies for meeting the staff's proposal are essentially motorcycle applications of automotive technologies that have been in use for almost two decades. Because these systems are relatively well understood, it is reasonable to assume that the most likely hardware to be used for meeting the standards will not introduce liability issues or administrative cost increases. Consequently, no extra costs under this category have been included.

Investment Recovery

This portion of the cost analysis includes accounting for machinery and equipment to manufacture parts, assembly plant changes (automation), vehicle development (engineering), and the cost of capital recovery.

Machinery and Equipment to Manufacture Parts

Because virtually all of the new components will be produced by suppliers, the costs of machinery and equipment to manufacture the parts needed to meet the standards are already included in the component costs.

Assembly Plant Changes (Automation)

The primary changes from an assembly point of view are in the exhaust system configuration. Because exhaust systems are usually installed as an assembly, current assembly plant operations should not be affected by the use of exhaust systems designed to meet the standards.

Vehicle Development

Once the vehicle development program is transferred from the advanced engineering team, calibration and certification engineers complete the emission control system design process. We added motorcycle development costs for the facility, equipment and personnel for an additional motorcycle dynamometer, as shown in Table VI-4. Such equipment would be used for the optimization of fuel injection systems and three-way catalysts on new model motorcycles. We again amortized these costs over 15,000 motorcycles per year for 15 years.

Table VI-4. Estimated Vehicle Development Costs (1)

Facility	Engineering Staff for Vehicle Development		Engineering Staff Cost (2)	Facility Cost	Additional Equipment (3)	Cost/Vehicle (4)
	(person-yrs) [A]	(person-hrs) [B]	(in \$) [C]	(in \$) [D]	(in \$) [E]	(in \$/vehicle) [F]
Motorcycle Dynamometer	3	6240	374,400	200,000	100,000	3.00
Total						3.00

Notes: [F] = ([C] + [D] + [E]) / (15,000 bikes/yr x 15 yr); [C] = [B] x \$60/hr; [B] = [A] x 8 hr/day x 260 day/yr

- (1) For vehicle calibration or certification effort
- (2) Development cost includes personnel, overhead and other miscellaneous costs at a total rate of \$60/hr.
- (3) Cost distributed over 15,000 vehicles per year for total of 15 years.
- (4) Additional equipment cost covers more sophisticated emission measurement equipment and emission testing costs.

Capital Recovery

The cost of capital recovery (return on investment) was calculated at six percent of the total costs to the manufacturer. At least one large-volume automobile manufacturer employs such an approach to calculate the cost of capital recovery. Table VI-5 shows the staff's estimated cost of capital recovery based on this methodology.

Table VI-5. Estimated Capital Recovery Costs

	Capital Recovery (6% of Total Manufacturer Costs), in dollars	
	Engine Displacement (280 to 699 cc)	Engine Displacement (≥ 700 cc)
Tier-1	1.65	2.50
Tier-1	4.32	5.64

Dealer Costs

Dealership costs include accounting for operating costs and the cost of capital recovery. Since the price of the motorcycle would likely increase due to the proposed standards, it is appropriate to account for the additional interest that the dealer would pay for financing the cost of the motorcycle and to cover the commission sales persons will receive as well. An interest rate of six percent was assumed on the incremental cost, and on average, motorcycles were presumed to remain in the dealership inventory for one quarter. The increased commission paid to sales persons was calculated at three percent of the differential wholesale price. Dealer costs based on these assumptions are shown in Table VI-6.

Table VI-6. Estimated Dealer Costs

	Operating Cost (in \$)		Cost of Capital Recovery (in \$)	
	Engine 280 to 699 cc	Engine \geq 700 cc	Engine 280 to 699 cc	Engine \geq 700 cc
Tier-1	0.87	1.32	0.45	0.68
Tier-2	2.29	2.99	1.55	1.19

Incremental Cost of the Proposed Standards

For each proposed HC+NO_x standard, the incremental cost is the sum of the individual variable, support, investment recovery, and capital recovery costs for the manufacturer plus the dealership costs. Tables VI-7 shows the incremental costs to the consumer of the proposed 1.4 g/km and 0.8 g/km standards, respectively; incremental costs shown are relative to a new 1998 motorcycle.

Table VI-7. Incremental Cost of Staff Proposal Over Cost of Current Standard

Tier-1 Compliance Level: 1.4 g/km HC+NOx		Cost (in \$)	
Type of Cost	Specific	Engine 280 to 699 cc	Engine ≥ 700 cc
Manufacturer Variable Costs	Components	13.76	27.88
	Assembly, Warranty, Shipping	3.00	3.00
Manufacturer Support Costs	Research	9.23	9.23
	Legal, Administrative	0.00	0.00
Manufacturer Investment Recovery Costs	Machinery & Equipment	0.00	0.00
	Assembly Plant Changes	0.00	0.00
	Vehicle Development	1.50	1.50
Manufacturer Capital Recovery Costs	N/A	1.65	2.50
Dealership Costs	Operating Costs	0.87	1.32
	Capital Recovery	0.45	0.68
Total Incremental Cost to Consumer, \$		30.46	46.11

Tier-2 Compliance Level: 0.8 g/km HC+NOx		Cost (in \$)	
Type of Cost	Specific	Engine 280 to 699 cc	Engine ≥ 700 cc
Manufacturer Variable Costs	Components	59.80	81.81
	Assembly, Warranty, Shipping	7.00	7.00
Manufacturer Support Costs	Research	9.23	9.23
	Legal, Administrative	0.00	0.00
Manufacturer Investment Recovery Costs	Machinery & Equipment	0.00	0.00
	Assembly Plant Changes	0.00	0.00
	Vehicle Development	3.00	3.00
Manufacturer Capital Recovery Costs	N/A	4.32	5.64
Dealership Costs	Operating Costs	2.29	2.99
	Capital Recovery	1.19	1.55
Total Incremental Cost to Consumer, \$		75.65	99.68

Note: Sales-weighted Average (SWA) Incremental Cost Increase = (Inc. Cost 280-699cc)*(0.10)+(Inc. Cost 700cc+)*(0.90)
 Example: SWA Incremental Cost to Consumer for Tier-2 = (75.65)*(0.10)+(99.68)*(0.90) = 97

Cost-effectiveness of Proposed Motorcycle Standards

Summary

To determine the proposal’s cost-effectiveness, we first calculated the exhaust emission benefits of the proposed motorcycle standards (relative to the corresponding 1998 California motorcycle) using the EMFAC7G emission model. We then calculated the cost-effectiveness by dividing the total incremental cost to the consumer by the total ROG and NOx emission reductions. As shown in Table VI-10, the estimated overall cost-effectiveness ranges from about \$3 per pound to about \$5.60 per pound of HC and NOx reduced, which compares favorably with other ARB-adopted emission control measures.

Cost-effectiveness of a California-only 0.8 g/km Motorcycle

In performing the cost analysis, we assumed that each manufacturer would produce a “national” motorcycle meeting a 0.8 g/km HC+NO_x standard (i.e., a 50-state motorcycle) rather than a California-only motorcycle meeting the 0.8 g/km standard in 2008. This assumption is reasonable for most cases because the production of a 50-state motorcycle helps to achieve economies of scale by distributing the costs over a larger fleet, thereby reducing the cost increases on individual motorcycles. Similarly, the automobile industry agreed to produce a “national LEV,” resulting in 50-state vehicles that were only slightly higher in cost than LEV-Tier I vehicles, while still providing significant emission reductions. We believe that such an approach would not only allow manufacturers to meet the 0.8 g/km standard in a cost-effective manner, but it would also contribute to California’s air quality by alleviating the traditional concerns of migration of non-California-compliant motorcycles from other states to California, either permanently or due to tourism.

On the other hand, some manufacturers believe that a 0.8 g/km standard could cause manufacturers to produce California-only and 49-state motorcycles. To determine the impacts to the proposal’s cost-effectiveness under such a “worst-case” scenario, we performed a separate analysis using the total incremental cost to the consumer of a California-only 0.8 g/km motorcycle. In that analysis, we estimated that the incremental hardware cost would double to account for California production volumes being significantly smaller than national volumes. Also, the research and vehicle development costs were amortized over a California volume instead of over a national volume. Under this scenario, we estimated the incremental cost to consumers of a California-only 0.8 g/km motorcycle standard to be \$200, with a corresponding cost-effectiveness of \$5.60 per pound of HC and NO_x emissions reduced. Thus, even under a worst-case scenario, the cost-effectiveness of the proposal is still of the same order of magnitude as other recently adopted emission control measures.

VII.

ENVIRONMENTAL IMPACTS OF PROPOSED AMENDMENTS

A. Projected Benefits

It is well established that, for California, reductions in hydrocarbon (HC) and oxides of nitrogen (NO_x) emissions will lower ambient ozone levels. (Note: for purposes of this discussion, HC is equivalent to “reactive organic gas” or ROG). Hydrocarbons and NO_x also undergo transformations in the air to form particulate matter (PM). Therefore, the staff’s proposal to reduce HC and NO_x levels from motorcycles will provide environmental benefits primarily from the reduction of ozone and PM.

California’s plan for achieving the one-hour federal ambient ozone standard is contained in the State Implementation Plan for Ozone (ozone SIP), approved by the Board in 1994. In essence, the ozone SIP contains all the measures and commitments which, collectively, would reduce ozone precursor emissions to the levels needed to attain the ozone standard. For the South Coast Air Basin (SoCAB), in addition to the specific measures defined in the ozone SIP, additional emission reductions of approximately 75 tons per day (tpd) of ROG and NO_x are needed to attain the 1-hour federal ozone standard. These additional emission reductions are often referred to as the mobile source “black box.” The staff’s proposed amendments will help cover shortfalls in defined ARB measures and make progress toward the black box.

Although the SoCAB is the only area in the State with a black box, the emission reductions from the staff’s proposal are needed statewide. The proposed on-road motorcycle amendments will help achieve and maintain the federal 1-hour ozone standard in regions such as the San Joaquin Valley and the Sacramento area; the federal 8-hour ozone and particulate matter standards in a number of areas; and the State ozone and particulate matter standards throughout California.

In the current official inventory for 2010, statewide on-road motorcycle emissions account for 14.5 tpd of ROG and NO_x emissions, as shown in Table VII-1. Under the 1994 SIP, on-road motorcycles account for 6.29 tpd of ROG and NO_x emissions in the SoCAB. However, ARB has continued to improve the inventory through surveys, emissions testing, and updated usage data provided by industry representatives. As seen in the table, the staff’s current updated estimates for statewide and SoCAB 2010 motorcycle emissions are lower than the official inventories for that year. These changes are due to revised activity data and emission factors.

Table VII-1. 2010 On-Road Motorcycle Statewide & SoCAB Emission Inventories (TPD)

Statewide Inventory		ARB Staff-Updated Estimate*	
Pollutant	Current Official Inventory	Baseline	With Staff Proposal
ROG (HC)	9.6	4.6	3.8
NOx	4.9	3.1	2.6
SoCAB Inventory		ARB Staff-Updated Estimate*	
Pollutant	Current Official Inventory	Baseline	With Staff Proposal
ROG (HC)	4.2	1.9	1.6
NOx	2.1	1.3	1.1

*Based on refinements to the inventory using updated data from the MIC; DMV registrations; updated parameters from EMFAC7X; and data from ARB testing, certification, and current surveillance project.

Table VII-2 shows the estimated statewide and SoCAB emission benefits from this rulemaking. Using the emission model EMFAC7G as modified with revised activity data (MIC, March 1998) and emission factors, we project the new standards will reduce statewide HC+NOx emissions by 1.3 tpd in 2010 and by 2.9 tpd in 2020. Similarly, we project the new standards will reduce SoCAB HC+NOx emissions by 0.47 tpd in 2010 and 1.0 tpd in 2020. The higher emission benefits in the long-term reflect the relatively long lifetime of motorcycles (estimated at 14 years) and the resulting low turnover; therefore, we do not project full fleet turnover to the Tier-2 standard until around 2020. These new reductions would help cover shortfalls in defined ARB measures and make progress toward the black box.

Table VII-2. Projected Tier-1 and Tier-2 HC+NOx Emission Benefits

Pollutant	Statewide Reductions, TPD		SoCAB Reductions, TPD	
	Year = 2010	2020	2010	2020
HC	0.85	2.0	0.30	0.71
NOx	0.48	0.91	0.17	0.32

Basis: modified EMFAC7G, assumes 34% tampering rate (MIC, 8/98)

B. Potential Mitigating Factors

The MIC claims that standards which force the widespread use of catalytic converters will reduce or even negate the projected emission reductions because of resultant consumer tampering and migration/tourism of 49-state motorcycles into California. Given the incomplete data on these activities, it is difficult to project with any certainty what effects they may have on the staff

proposal's benefits. However, as discussed in Chapters V and VI, we do not expect our proposal to result in the widespread use of catalysts; rather, we expect catalysts will be used only in selected product lines to the extent necessary under the corporate averaging provision. Thus, our proposal should minimize whatever mitigating impacts these activities may have, if any.

Tampering. The MIC provided data from tampering surveys it conducts every five years. (MIC, August 1998). Because they were designed to address noise ordinances, the surveys provide data pertaining only to the tampering of exhaust equipment (primarily the removal or replacement of mufflers) and therefore give an incomplete picture of typical tampering and its effects. Even with this limitation, the surveys do suggest that tampering rates may be on the order of 34% (i.e., 34 out of every 100 motorcycle riders across the U.S. have tampered with their exhaust equipment). The MIC believes that such surveys, and its experiences with consumers, suggest tampering which affects emission levels may be an intractable problem. (MIC, October 1998b) Indeed, the MIC believes that emission standards which force manufacturers to install catalytic converters on all or nearly all motorcycles will exacerbate current tampering rates, i.e., riders will more likely modify their vehicles to remove the catalysts for "improved" performance.

We strongly disagree that tampering is necessarily an intractable problem. As we noted in Chapter II, on-road motorcycles are currently exempt from the regular inspection and maintenance (I&M or "Smog Check") requirements that apply to automobiles and other vehicles. While tampering that affects the emission levels is already prohibited under existing California law (Vehicle Code 27156), enforcement of those requirements is limited. Thus, one cannot conclude that tampering is an inherent and intractable activity associated with motorcycles; indeed, it is more likely that tampering rates are inversely proportional to the level of enforcement, and that improved monitoring of the emissions control equipment installed by the manufacturers would significantly reduce tampering rates.

At current enforcement levels, motorcycles are essentially at the same state that automobiles were in when computerized controls and catalysts were first placed on cars. At that time, car owners also tampered with the emission controls in the mistaken belief that improved performance would result. However, our experience shows that, as consumers acclimated to the new technologies, tampering became limited to certain sectors of the population. In addition, as engine systems become more "high-tech" and optimized with emission controls (and improved performance), whatever performance benefits consumers perceive from tampering should decrease. Based on our experiences with automobiles, we expect that the majority of motorcycle riders will become accustomed to emission controls, resulting in decreased tampering rates and improved effectiveness of the staff's proposal over time. Moreover, improved consumer education or enforcement of anti-tampering requirements should help consumers to better understand the purpose and benefits of the emission controls. As we discuss in Chapter X, we will be working with the MIC and other stakeholders to determine the best methods to improve consumer education and reduce tampering rates.

Finally, it is important to note that the emission benefits we project for this rulemaking already incorporate the 34% tampering rate cited by the MIC. While the MIC's survey data is inconclusive with regard to engine systems tampering, we incorporated the 34% tampering rate in our projections to be conservative. Thus, even if we assume that tampering affects emission levels in proportion to the documented tampering rates, we still project the staff proposal will achieve emission reductions that will help ensure continued progress toward meeting the State and federal air quality standards.

Migration & Tourism. The MIC also claims that migration and tourism of 49-state motorcycles into California will offset, to a large degree, the emission reductions from standards that force the widespread use of catalytic converters. (MIC, Sept. 1998; MIC, Oct. 1998b) Essentially, the MIC believes that catalyst-forcing standards will result in a bifurcation of motorcycle production, with manufacturers making separate lines of California-only and 49-state motorcycles. Consequently, 49-state motorcycles (with their higher allowable emissions) will impact the projected benefits from staff's proposal, either by migrating into California or from temporary visits.

While the exact impacts migration and tourism may have on overall emission levels are unclear, we believe our proposal will minimize whatever impacts such activities may have, if any. As stated previously, the staff's proposal does not require the widespread use of advanced catalysts, but rather should result in the use of catalysts only on selected product lines. Because of this, we believe that, for most manufacturers, a fully bifurcated California-only versus 49-state motorcycle production scenario is unlikely. Thus, our proposal should reduce the potential for 49-state motorcycles to adversely impact statewide emission levels through migration or tourism.

Current ARB certification data and established economic principles also support this belief. According to the 1998 certification database, some manufacturers produce California-only and 49-state motorcycles, while others produce 50-state motorcycles. Manufacturers who currently produce 50-state motorcycles do so even though the existing California emission standards are 3 to 5 times more stringent than the current federal 5 g/km HC-only standard. (See Title 40, Code of Federal Regulations, Part 86, Subpart E). The fact that these manufacturers produce a 50-state motorcycle despite the difference in State and federal emission requirements strongly suggests there are significant economic advantages to producing a 50-state motorcycle (e.g., economies of scale, reduced distribution costs, production uniformity). We expect the economic advantages from producing a uniform, 50-state motorcycle will remain in effect for manufacturers under the staff's proposal.

VIII.

ANALYSIS OF REGULATORY ALTERNATIVES

Health and Safety Code section 57005 requires the ARB to perform a cost analysis of alternatives to the proposed regulation under specified circumstances. The analysis is required when the proposed regulation is a major regulation, which is defined as a regulation that will have a potential cost to California business enterprises in an amount exceeding ten million dollars in any single year. As discussed in Chapter VI, we determined that the annual cost of the staff's proposal will be approximately \$1.3 million in 2004 and \$3.2 million in 2008. Thus, the staff's proposal is not a major regulation under Health and Safety Code section 57005. Nevertheless, we recognize the importance of evaluating alternatives to the proposal which can achieve equivalent reductions within the same timeframe and at equal or less cost than the staff's proposal. We therefore considered the following regulatory alternatives to the proposed amendments. Compared to these alternatives, our current proposal represents a fair and workable approach to achieving significant emission reductions with reasonable costs to industry and consumers.

A. Adopt No New Standards

As discussed previously, essentially all possible control measures which the ARB determines are technologically and commercially feasible must be implemented to meet the SIP requirements. A commitment to amend the current on-road motorcycle regulation was not a formal part of the SIP when it was adopted in 1994, primarily because the ARB believed at that time that sufficient reductions could be achieved from the commitments already in the SIP. However, we have subsequently determined that additional control measures need to be implemented in order to meet the SIP commitments and contribute to achieving other air quality standards. This is especially true for meeting the so-called SIP "black box" commitment. Lowering the on-road motorcycle emission standards will help fulfill that commitment. Without the emission reductions to be achieved with the proposed standards, the SIP requirements will either not be met or will need to be achieved at the expense of other vehicular categories.

From an equity standpoint, amending the existing motorcycle limits as staff proposes will bring this segment of the motor vehicle industry up to date with technological improvements that have been used extensively by automobiles, trucks, and other motor vehicles for many years. It is important to recall that the original motorcycle regulation was adopted in the late 1970s and was last amended in 1984. Since then, automobiles and other motor vehicles have been required to use cutting-edge emission control technologies. Thus, we believe it is appropriate to ask the motorcycle industry to help reduce air pollution along with other, more-heavily-regulated motor vehicle categories.

B. Adopt Less Stringent Standards

As discussed in Chapter V, we evaluated two industry proposals: a proposal from one of the six major manufacturers and the other from the Motorcycle Industry Council. Both of these proposals are less stringent than our proposal and would achieve significantly less emission reductions. The manufacturer's proposal, a 1.4 g/km HC+NO_x standard for Model Year 2004, is identical to our Tier-1 proposal of 1.4 g/km. However, this industry proposal lacks a second-tier standard. Instead, the proposal relies on a mid-course technology review as a pre-requisite to the adoption of a second-tier standard. Thus, this industry proposal provides little or no incentive for manufacturers to begin their R&D efforts now toward meeting a more challenging, second-tier standard that achieves greater reductions. From a benefits standpoint, we project this proposal would achieve about 0.6 tpd HC+NO_x statewide reduction by 2010, which rises marginally to about 0.7 tpd HC+NO_x reduction by 2020 (primarily from projected sales growth).

Unlike the manufacturer's proposal, the Motorcycle Industry Council proposes a two-tier approach similar to ARB staff's proposal. The MIC's proposed first-tier standard of 1.5 g/km HC+NO_x is based on the use of engine modifications without catalytic converters, an approach also used in ARB staff's first-tier proposal. However, the MIC's proposed second-tier standard of 1.2 g/km HC+NO_x by 2008 achieves significantly less reductions than ARB staff's proposal of 0.8 g/km. To illustrate, the MIC's proposal would reduce the 2010 statewide inventory by about 0.7 tpd HC+NO_x, as compared to ARB staff's proposal, which we expect will reduce the inventory by about 1.3 tpd. The difference is even more significant when the proposals' benefits are projected further into the future (to account for full fleet turnover). By 2020, the MIC's proposal would reduce statewide HC+NO_x emissions by about 1.2 tpd, whereas the staff's proposal would reduce emissions by about 2.9 tpd. Thus, the MIC's proposal would provide significantly less reductions than ARB staff's proposal.

C. Adopt More Stringent Standards

At the beginning of this rulemaking, we proposed a single, 0.2 g/km HC+NO_x standard designed to reduce HC and NO_x emissions by about 90% and 80%, respectively. This proposal probably represents the lower bound on exhaust emissions that can be achieved through extensive use of "conventional" technologies used in automobiles and some motorcycles: three-way, close-coupled/closed-loop catalytic converters, secondary air injection, electronic fuel injection, and other engine modifications. We based this proposal on literature searches and several discussions with members of the Manufacturers of Emission Controls Association (MECA). While a 0.2 g/km or some lower HC+NO_x limit is technically feasible, it would be very challenging to manufacturers and probably not be cost-effective. Therefore, we ultimately rejected this standard because, with current and foreseeable technologies, it is likely to have some significant impacts on various parameters that are important to manufacturers and consumers, including cost, driveability, safety, and aesthetics.

As discussed in Chapter III, our proposal underwent several revisions before arriving at the current proposal. At the first workshop in July 1998, we proposed another set of standards which were more stringent than the current proposal (a 0.6-0.8 g/km HC+NO_x Tier-1 limit and a 0.3-0.4 g/km Tier-2 limit). Based on further technical discussions with industry representatives and information obtained during and subsequent to the second public workshop in October 1998, we revised our proposal two more times prior to the current proposed limits. Our analysis indicated these earlier-proposed standards are feasible but more costly than the current proposal. Thus, staff underwent an extensive three-step revision process in which we evaluated three, more stringent proposals before arriving at the current proposed limits.

D. Conclusions

We evaluated a variety of regulatory alternatives and found that the current proposal represents a reasonable balance of potential emission benefits, use of demonstrated and emerging technologies, and minimized economic impacts.

IX.

OUTSTANDING ISSUES

Staff presented the essential elements of the proposed amendments through two public workshops and numerous individual meetings with stakeholders. The proposed Tier-1 standard, the need for a Tier-2 standard, the corporate averaging provision and the small-volume-manufacturer provision are generally consistent with industry views. However, some issues did arise with regard to the magnitude of projected emission reductions and the appropriateness of obtaining such reductions from this vehicular category; the certainty of Tier-2 compliant technology development; and the potential impacts equipment tampering by consumers may have on the projected emission reductions. These issues are discussed as follows.

A. Magnitude of Reductions and Appropriateness of Obtaining the Reductions from On-road Motorcycles

The Motorcycle Industry Council has raised concerns regarding the relative magnitude of the emission reductions to be achieved with staff's proposal. As noted in Chapter VII, the projected HC+NO_x emission reductions upon full implementation of staff's proposal are 1.3 tpd by 2010 and 2.9 tpd by 2020. Essentially, the issue raised by the MIC is whether the magnitude of these emission reductions justifies obtaining such reductions from the on-road motorcycle category, rather than from another source. As discussed below, the air pollution situation in California requires the ARB to consider all possible ways to reduce emissions from all sources and adopt those measures which reduce emissions cost-effectively. Moreover, equity requires that we ask all industries and activities, which contribute to the air pollution problem, to also contribute to the overall solution.

In previous chapters of this report, we discussed the need to achieve emission reductions from every feasible source to meet the SIP commitments. After several decades of regulatory programs, it is generally recognized that the "easy and large" reductions from a few, very visible source categories have already been achieved (e.g., cars, refineries, smokestacks). Future incremental reductions will be achieved from many smaller sources with greater effort. For example, automobiles have already been required to achieve emission reductions of nearly 95% or more relative to their pre-regulatory levels in the 1960s. However, as vehicle miles traveled (VMT) increases and emission control technologies progress, we continue to seek the most feasible reductions we can achieve from cars and other sources. The recently proposed amendments to the Low Emission Vehicle (LEV) and Zero Emissions Vehicle (ZEV) regulations strive to reduce automobile emissions even further. Other categories, such as off-road motorcycles, heavy-duty trucks, and utility engines have also been recently regulated and required to reduce emissions.

To further illustrate the need to achieve all feasible reductions, we note that the ARB has recently regulated very small emission sources which, traditionally, had never been required to reduce ozone precursor emissions. A prime example of this is the ARB's consumer products program, which is designed to reduce emissions of hydrocarbons from solvent-containing products used by consumers and businesses.

The most recent amendments to the consumer products regulation ("Mid-Term Measures" or Phase III) added 25 new hydrocarbon limits on 18 individual categories of consumer products, ranging from automotive rubbing compounds to wasp and hornet insecticides. (Title 17, CCR, sections 94507--94517). Of these 25 limits, 21 had emission reductions that were less than the tonnage reductions projected for on-road motorcycles under the staff's proposal. Indeed, 14 of these 21 limits had projected statewide emission reductions of 500 pounds per day (0.25 tpd) or less by 2005. (ARB, June 1997). Moreover, the annual cost of reducing consumer product emissions was projected to be up to ten times higher than the cost projected for the staff's proposal for motorcycles. (*Id.* at Vol-II, Ch-VIII, p. 17). It is clear that most of these consumer product categories have reduction potentials lower than the on-motorcycle category under staff's proposal. However, the fact that consumer products are regulated in California provides direct evidence of the need to evaluate all possible sources of ozone and PM precursor emissions to achieve whatever reductions are feasible and cost-effective.

When the ARB adopts measures to reduce emissions, the primary goal of such efforts is to achieve the most reductions that the affected industry can cost-effectively implement. Through careful balancing of industry, environmental, and consumer needs, the ARB establishes standards that maximize reductions while minimizing impacts. Since all the "easy" reductions have already been achieved, and measures under development are achieving maximum reductions at increasing costs, it is difficult to see what sources are left that have not already been regulated and can replace the reductions we are seeking from on-road motorcycles. Even if such new or already-regulated sources were identified, reductions from on-road motorcycles and all other feasible sources would still be required, given the very large magnitude of reductions needed to meet State and federal air quality standards.

B. Certainty in Development of Tier-2 Compliant Technology

Some concern has been raised regarding the development of Tier-2 compliant technology. Specifically, some industry members have raised the issue of whether advanced emission controls can ever be implemented for some motorcycles. It is generally recognized that, given no other constraints, engine systems and catalysts are currently available which can meet the proposed Tier-2 standard and even lower levels. (MIC, Oct. 1998a) However, under real-world conditions, manufacturers have to balance available technology with costs and constraints unique to motorcycles. We recognize that motorcycles are not automobiles and have unique challenges with regard to limited space available for installing emission controls, vibrational stresses, rider safety, and cost impacts. We are also aware that installing emission controls on a motorcycle

while maintaining acceptable aesthetic qualities will challenge manufacturers on at least some product lines.

We designed our Tier-2 proposed standard to address these and other concerns. As stated previously, the Tier-2 standard is expected to result in the use of catalysts on selected product lines, rather than on most motorcycles. Thus, the universal application of catalytic converters will not be required; manufacturers would need to expend their R&D resources on engine systems and pulse-air technology, with efforts spent to develop catalysts only to the extent required under corporate averaging to reach an average level of 0.8 g/km HC+NO_x. As discussed earlier, we expect a maximum of 60% of the market would need to use catalytic converters. Given that advanced engine systems and catalytic converters have already been demonstrated on commercially-available motorcycles for several years, we believe manufacturers can meet the challenges of designing and installing the necessary equipment within the next 9 years.

Even for motorcycles on which catalysts are required, the catalyst and associated equipment is challenging but not impossible, and successful catalyst use has already been demonstrated on nearly all BMW motorcycles (BMW, 1998), some Japanese product lines, and even one Harley-Davidson line. Unlike engine modifications, secondary pulse-air injection, and other engine system changes we expect, catalytic converters will require some effort to installed in an acceptable manner. Riders will need to be protected from the catalyst's heat and, when catalyst visibility would be undesirable, some effort will be required to install the catalysts within the muffler system, under the engine, or elsewhere where it would not be visible. Vibrational and other engine stresses will require careful placement of the catalyst to balance the need to maintain heat input from the engine versus the need to minimize stresses on the catalyst. These and other challenges have already been met by manufacturers on some existing motorcycles, and we anticipate they will be able to resolve any design and installation issues with the remaining motorcycles within the next 9 years.

C. Potential Impacts on Program Effectiveness from Equipment Tampering

From anecdotal information and limited surveillance data, we know that a portion of the motorcycle riding population tampers or has tampered with (i.e., removed, replaced, or modified) the original equipment on their motorcycles. Such tampering includes changes that can be detrimental or beneficial to the motorcycle's emission levels. These activities frequently involve the replacement of exhaust systems, carburetor jet modifications, "tweaking" of the electronic controls, removal of catalytic converters, or other activities that may have potential negative (or positive) impacts on emission levels. According to the MIC's limited data on exhaust-only tampering, consumer tampering may be on the order of 34 percent. (MIC, Oct. 1998a)

As discussed in Chapter X ("Future Activities"), we plan to work closely with the MIC and other stakeholders to comprehensively document tampering rates and the effects tampering has on emission levels. We anticipate our cooperative efforts will help identify the sector(s) of the rider population which tampers with original equipment on motorcycles. Through improved

consumer education and, if necessary, increased enforcement of existing anti-tampering statutes, we hope to better quantify and ultimately reduce whatever tampering is occurring. We also plan to work closely with manufacturers to ensure that their Tier-1 and Tier-2 compliant technologies are as tamper-resistant as possible. Current European regulations require tamper-proof designs to address noise concerns, which we will be evaluating as a model for any tamper-resistant requirements that may be necessary to maximize the effectiveness of the staff's proposal. (Directive 97/24/EC, 1997)

X.

FUTURE ACTIVITIES

A. Further Refinement of the Emissions Inventory

As noted earlier, the Motorcycle Industry Council was instrumental in refining the emissions inventory. Further efforts will enable staff to continue refining the inventory as better data become available. First, we will work with the MIC and other industry representatives to refine vehicle activity data and deterioration factors. We will also discuss with the MIC the feasibility of improving its 5-year survey of equipment tampering to better gauge the rates of illegal engine modifications and exhaust system tampering. Finally, we will discuss with industry representatives the most effective methods for identifying and discouraging illegal tampering, which would benefit the proposal's emission reductions. We look forward to coordinating our efforts with the MIC and other industry representatives.

As with virtually all other sources of air pollution, the on-road motorcycle emissions inventory will undergo refinements in the future as we gain a better understanding of the factors that influence emissions from this category. This continual improvement in emissions data is a natural result of better surveys, testing, enforcement, and other means of information gathering. The ARB staff are committed to refining the inventory for all sources of emissions as more accurate information becomes available. It should be emphasized, however, that this refinement is an on-going process which should not preclude the adoption of control measures based on the best data currently available to staff. The staff's proposal, its commercial and economic impacts, and its benefits were all evaluated based on the best available data, much of which was supplied by the MIC and other industry representatives. Therefore, the staff's proposal represents the most reasonable set of standards given our current understanding of the on-road motorcycle industry, the technologies needed to reduce emissions, and consumer behavior patterns that affect emissions.

B. 2006 Progress Review

Our discussions with manufacturers and suppliers, as well as our review of the 1998 ARB on-road motorcycle certification database, strongly support our belief that manufacturers will be able to comply with both Tier-1 and Tier-2 standards in the time provided. In particular, the proposed Tier-2 standard of 0.8 g/km HC+NO_x and the corporate averaging provision give manufacturers increased flexibility in deciding which engine families will need catalytic converters and which can do without catalysts. To ensure that manufacturers are adequately progressing in their efforts to comply, we will be conducting a mid-course status review. Because the Tier-1 standard is based on the widespread use of reasonably available and demonstrated engine modifications, we do not believe a technology review prior to 2004 is necessary. Moreover, we believe manufacturers will soon begin to spend the bulk of their R&D efforts to meet the Tier-2 standard. We are therefore proposing a progress review in 2006 to:

(1) evaluate the success, cost, and consumer acceptance of engine modifications employed to meet Tier-1, and (2) review and discuss manufacturers' efforts to meet Tier-2, which at that point should be well under way. We believe a 2006 progress review will provide sufficient time for mid-course corrections if needed to address unforeseen circumstances.

REFERENCES

Title 13, California Code of Regulations, section 1958.

Resolution 84-11, Air Resources Board, Agenda Item Nos. 84-6-4 & 84-7-1 (April 26, 1984).

Air Resources Board, "The California State Implementation Plan for Ozone," Volumes I-IV, November 1994.

Air Resources Board, "1995 Estimated Annual Average Emissions Statewide," (visited 10/16/98) <<http://www.arb.ca.gov/ceidars/emmsumcat>>.

Air Resources Board, EMFAC7G (one of the four computer models comprising the Motor Vehicle Emission Inventory (MVEI) Models, the others being CALIMFAC, WEIGHT, and BURDEN), (last modified 10/1/98) <<http://www.arb.ca.gov/msei/mvei/program.exe>>.

Letter from James R. Ryden, Administrative Law Judge, Air Resources Board, to William C. Robb, II, American Motorcycling Manufacturing (March 17, 1998).

Air Resources Board, "Revisiting the On-Road Motorcycle Regulation," Public Workshop Slide Presentation, El Monte, CA (July 1, 1998a).

Air Resources Board, "Revisiting the On-Road Motorcycle Regulation," Public Workshop #2 Slide Presentation, El Monte, CA (October 7, 1998b).

Tim Hoelter, Vice-President-International Trade and Regulatory Affairs, Harley-Davidson, Address at ARB Public Workshop #2 "Revisiting the On-Road Motorcycle Regulation," (October 7, 1998).

"1997 Motorcycle Statistical Annual," Motorcycle Industry Council (MIC), January 1997.

"The Motorcycle Industry in Europe," ACEM Pollution Research Programme on Motorcycles, ACEM Pollution Working Group, March 1998.

"Motorcycle Industry Council Proposal for Revising Exhaust Emission Standards for On-Road Motorcycles," MIC Presentation to the California Air Resources Board, p.3 (October 7, 1998a).

BMW, "Info Box - Technical Encyclopedia," p.2, (visited 4/13/98) <<http://www.bike.bmw.com/english/infobox/lexicon/c.html>>.

MBNet, "[Yamaha] GTS1000A Development Concept," p.3, <<http://www.mbnet.mb.ca/~neelin/motorcycle/concept.html>>.

Mazda, "Mazda Develops New Three-Way Catalyst — Further Reduces Pollutants in Exhaust Emissions," p.1, (visited 7/24/98) <<http://www.e.mazda.co.jp/Publicity/9803/980317.html>>.

Degussa, "What's New," pp.1-2, (visited 7/24/98)
<http://www.degussa.com/html/2_18_98_2.html>.

R.J. Locker, C.B. Sawyer, and P.S. Schmitt, "Demonstration of High Temperature Durability for Oval Ceramic Catalytic Converters-2," Society of Automotive Engineers (SAE) Paper No. 980042 (1998).

R.N. Carter, et al., "Laboratory Evaluation of Ultra-Short Metal Monolith Catalyst," SAE Paper No. 980672 (1998).

SAE Virtual Press Room, "Emitec, Toyota Develop Revolutionary Foil to Reduce Automotive Emissions," (visited 7/28/98) <http://www.eisbrenner.com/vpr/v_emitec.htm> (February 23, 1998).

B. Williamson, J. Nunan, and K. Andersen, Allied Signal Environmental Catalysts, and J.M. Best, Delphi Energy & Energy Management, "Fatigue and Performance Data for Advanced Thin Wall Ceramic Catalysts," SAE Paper No. 980670 (1998).

R. Brück, et al., "New Ultra Thin Wall Metal Catalysts for Close-Coupled Applications," SAE Paper No. 980420 (February 23, 1998).

Y. Song, J. Jang, and G. Yeo, Hyundai Motor Company, and J. Lee, Heesung Engelhard Company, "Development of Single Coated Pd/Rh Three Way Catalyst for CCC Applications," SAE Paper No. 980666 (1998).

S. Taniguchi, T. Yoshikawa, and M. Horiuchi, International Catalyst Technology Company; D. Lindner and L. Mußmann, Degussa AG; and M. Jenkin, International Catalyst Technology; "New Low Cost and High Performance Catalyst-Single Layer Pd/Rh Catalyst Development," SAE Paper No. 980669 (February 23-26, 1998).

N. Kishi, et al., "Development of the Ultra Low Heat Capacity and High Insulating (ULOC) Exhaust Manifold for ULEV," SAE Paper No. 980937 (February 1998).

Harley-Davidson 1998 Parts Catalog.

Ellaird, John H., "Heat shielding foot rest for attachment to a motorcycle exhaust system," U.S. Patent # 4,023,821 (May 17, 1977).

H. Nebu, K. Komura, and T. Yamada, "Exhaust pipe cover for motorcycles," U.S. Patent # 4,699,232 (October 13, 1987).

H.W. Hoeptner, III, "Adjustable shield for motorcycle exhaust pipe," U.S. Patent # 4,955,193 (September 11, 1990).

O. Fumihiro, "Exhaust Pipe Structure of Motorcycle," Japan Patent # 08082214 (March 26, 1996).

Air Resources Board, "Staff Report: Initial Statement of Reasons — Proposed Amendments to California Exhaust and Evaporative Emission Standards and Test Procedures for Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles 'LEV II' and Proposed Amendments to California Motor Vehicle Certification Assembly Line and In-Use Test Requirement 'CAP 2000'," p.II-55 (September 18, 1998).

Letter from Pamela Amette, Vice-President, MIC, to James R. Ryden, Administrative Law Judge, ARB (August 14, 1998).

Thomas C. Austin, Sierra Research representing the MIC, Address at ARB Public Workshop #2 "Revisiting the On-Road Motorcycle Regulation," (October 7, 1998).

Air Resources Board, "Initial Statement of Reasons for Proposed Amendments to the California Consumer Products Regulation," Volume II, Chapter III, pp. 4-6, (June 6, 1997).

BMW, Motorcycle Specifications, (visited 7/28/98) <<http://www.bmwusacycles.com/machines>>.

European Commission Council Directive 97/24/EC, art.1, 1997 O.J. (L 226) 79.

**APPENDIX A: PROPOSED AMENDMENTS TO
THE ON-ROAD MOTORCYCLE REGULATION**

Proposed Regulation Order

Amend Title 13, California Code of Regulations, section 1958 to read as follows:

[Note: Proposed amendments for this rulemaking are shown in **bold underlined** text to indicate additions and ~~strikeout~~ to indicate deletions.]

§1958. Exhaust Emission Standards and Test Procedures — Motorcycles Manufactured on or after January 1, 1978.

- (a) This section shall be applicable to motorcycles produced on or after January 1, 1978. Motorcycles are excluded from the requirements of this section if:
 - (1) The engine displacement is less than 50 cubic centimeters, or
 - (2) An 80 kilogram (176 pound) driver cannot:
 - (A) start from a dead stop using only the engine, or
 - (B) exceed a maximum speed of 40 kilometers per hour (24.9 miles per hour) on a level paved surface.

- (b) Exhaust emissions from new street-use motorcycles, subject to registration and sold and registered in this state, shall not exceed:

Exhaust Emission Table of Standards
(grams per kilometer)

Model-Year	Engine Displacement (in cubic centimeters)	Exhaust Emission Standards (grams per kilometer)	
		Hydrocarbon (HC) + Oxides of Nitrogen (NOx)	Carbon Monoxide
1978 to 1979	50 to less than 170	5.0 (HC only)	17
1978 to 1979	170 to less than 750	5.0 + 0.0155(D-170)* (HC only)	17
1978 to 1979	750 or greater	14 (HC only)	17
1980 to 1981	All (50 cc or larger)	5.0 (HC only)	17
1982 and subsequent	50 cc to 279 cc	1.0 (HC only)	12
1982 through 1985 (manufactured prior to March 1, 1985)	280 cc or greater	2.5 (HC only)	12
1985 (manufactured after February 28, 1985) through 1987	280 cc or greater	1.4 (HC only), applied as a corporate average, ** provided that each engine family shall have only one applicable standard	12
1988 and subsequent through <u>2003</u>	280 cc to 699 cc	1.0 (HC only), applied as a corporate average, ** provided that each engine family shall have only one applicable standard	12
1988 and subsequent through <u>2003</u>	700 cc or greater	1.4 (HC only), applied as a corporate average, ** provided that each engine family shall have only one applicable standard	12
<u>2004 through 2007</u>	<u>280 cc or greater</u>	<u>1.4 (HC + NOx), applied as a corporate average, ** provided that each engine family shall have only one applicable standard</u>	<u>12</u>
<u>2008 and subsequent</u>	<u>280 cc or greater</u>	<u>0.8 (HC + NOx), applied as a corporate average, ** provided that each engine family shall have only one applicable standard</u>	<u>12</u>

*D = engine displacement of motorcycles in cubic centimeters.

**Compliance with a standard to be applied as a “corporate average” shall be determined as follows:

$$\frac{\sum_{J=1}^n (\text{PROD}_{jX}) (\text{STD}_{jX})}{\sum_{J=1}^n (\text{PROD}_{jX})} = \text{STD}_{Ca}$$

where,

- n = Class III motorcycle engine families (**engines with displacement of 280 cc or greater manufactured after February 28, 1985).**
- PROD_{jx} = Number of units of Class III engine family j produced for sale in California in model year x
- STD_{jx} = The manufacturer designated HC **or HC + NOx** emission standard, **whichever applies,** for engine family j in model year x, which shall be determined by the manufacturer subject to the following conditions:
- (1) ~~no individual engine family exhaust emission standard shall exceed 2.5 g/km, and~~
 - (1) **for Model Year 1988 through 2003 motorcycles with engine displacement of 280 cc or greater, no individual engine family exhaust emission standard shall exceed 2.5 g/km HC, and**
 - (2) **for Model Year 2004 and subsequent motorcycles with engine displacement of 280 cc or greater, no individual engine family exhaust emission standard shall exceed 2.5 g/km HC+NOx, and**
 - (3) no engine family designation or engine family exhaust emission standard shall be amended in a model year after the engine family is certified for the model year, and
 - (4) prior to sale or offering for sale in California, each engine family shall be certified in accordance with Section 1958(c) and shall be required to meet the manufacturer's designated HC **or HC + NOx** standard, **whichever applies,** as a condition of the certification Executive Order. Prior to certification the manufacturer shall also submit estimated production volumes for each engine family to be offered for sale in California.
- STD_{Ca} = A manufacturer's corporate average HC **or HC + NOx** exhaust emissions, **whichever applies,** from those California motorcycles subject to the California corporate average HC **or HC + NOx** exhaust emission standard, as established by an Executive Order certifying the California production for the model year. This order must be obtained prior to the issuance of certification Executive Orders for individual engine families for the model year and shall include but not be limited to the following requirements:
- (1) During the manufacturer's production year, for each engine family, the manufacturer shall provide the following information to the Executive Officer within 30 days after the last day in each calendar quarter:

- (aA) vehicle identification numbers and an explanation of the identification code;
- (bB) the total number of vehicles produced for sale in California and their applicable designated emissions standards.

(2) The manufacturer's average HC **or HC + NO_x** exhaust emissions, **whichever applies**, shall meet the **applicable** corporate average standard at the end of the manufacturer's production for the model year.

[Note: No changes are proposed for Section 1958(b)(3) through (e)]

(f) (1) **Small Volume Manufacturers:** Exhaust emission **standards for** from Class III motorcycles of small volume manufacturers ~~shall not be exceeded~~ **are as follows:**

- (A) **For Model Year 1984 through 2007, no motorcycle shall emit more than 2.5 grams per kilometer hydrocarbon for the 1984, 1985, 1986, and 1987 model years;**
- (B) **For Model Year 2008 and subsequent, no motorcycle shall exceed 1.4 grams per kilometer HC + NO_x.**

To obtain certification as a small volume manufacturer pursuant to this subsection, the manufacturer shall submit product information and estimated sales data with the certification application for each engine family sold in California. As a condition of obtaining certification as a small volume manufacturer, the manufacturer shall submit annually to the ~~state board~~ **Executive Officer** a summary of its efforts and progress toward meeting more stringent hydrocarbon **HC + NO_x** exhaust emission standards. The summary shall include a description of the manufacturer's current hydrocarbon **HC + NO_x** emission control development status, along with supporting test data, and future planned development work.

(2) For purposes of ~~this subsection~~ **(f)(1)(A)**, a small volume manufacturer is one which sells less than 5,000 new Class I, II, and III motorcycles per model year in California. **For purposes of subsection (f)(1)(B), a small volume manufacturer is one which sells no more than 1,000 new Class I, II, and III (combined) motorcycles in model year 2004 or any subsequent model year in California.**

(g) Early-Compliance Credits

Manufacturers which sell Class III motorcycles in California certified as meeting either a 0.8 g/km or 0.4 g/km HC+NOx level prior to Model Year 2008 can receive credits for use in the Model Year 2008 corporate average upon written approval by the Executive Officer. Each unit of Class III motorcycle sold between Model Years 1999 and 2008 and which meets the requirements of this subsection shall be multiplied by whichever X multiplier applies, as shown in the following table:

Table of Multipliers to Encourage Early Compliance with the Proposed Tier-2 Standard and Beyond

<u>Model Year Sold</u>	<u>Multiplier (X) for Use in MY 2008 Corporate Averaging</u>	
	<u>Early Tier-2 Compliant</u>	<u>Certified at 0.4 g/km HC+NOx</u>
<u>1999 through 2004</u>	<u>1.5</u>	<u>3.0</u>
<u>2005</u>	<u>1.375</u>	<u>2.5</u>
<u>2006</u>	<u>1.250</u>	<u>2.0</u>
<u>2007</u>	<u>1.125</u>	<u>1.5</u>
<u>2008 and subsequent</u>	<u>1.0</u>	<u>1.0</u>

Note: Each unit of early Tier-2 compliant and 0.4 g/km certified motorcycles is counted cumulatively toward the MY 2008 corporate average.

Note: Authority cited: Sections 39600, 39601, 43013, 43101, 43104, and 43107, Health and Safety Code. Reference: Sections 39002, 39003, 43000, 43013, 43100, 43101, 43104, and 43107, Health and Safety Code; and Cal. Stats. 83, Ch. 103.

APPENDIX B: REQUESTS FOR CONSULTATION, REQUESTS FOR INFORMATION

APPENDIX C: MEETING & WORKSHOP NOTICES, ATTENDEES' LISTS

Attendees of Small-Volume Manufacturers Group Meeting (May 5, 1998)	
Tom Cates	Mark Boyer (MFC)
J.C. Delaney	Robert Lounsbury (RAM Inc.)
Pamela Amette (MIC)	Lloyd Lounsbury (RAM Inc.)
Kathleen Wolf	J.C. Coker (CEE)
Heath Glennon	Bill Sterman (Powerparts Inc.)
Kraig Kavanagh (Ultra Cycles)	

Attendees of Public Workshop #1 (July 1, 1998)	
Tim Hurley (Pure Steel of America)	Jeff Shetler (Kawasaki)
Lee Chapin (Mikuni American Corp.)	Kathleen Wolf (K.H. Wolf Consulting)
Mihael Tyrrell (Honda)	Pamela Amette (MIC)
David Raney (Honda)	Ken Boyd (Engine Electronics, Inc.)
Scott Maas (Excelsior Henderson Motorcycle)	Edward Michel (Harley-Davidson)
William Freedman (McCutchen, Doyle, et al.)	Robert Alsip (Suzuki)
Dana Bell (AMA)	Thomas Austin (Sierra Research)
Dale McKinnon (MECA)	Peterson Publishing
Thomas Pugh (Yamaha)	John Paliwoda (CMDA)
SEMA	CA Motorcycle Company

Attendees of Public Workshop #2 (October 7, 1998)	
Don Fuller	Jeff Noonan (JE Pistons)
Ken Bush (Suzuki)	Jeff Shetler (Kawasaki)
Jeff Link (Suzuki)	Tom Pugh (Yamaha)
Kathleen Wolf	Ryan Tovatt (Tovatt Engineering)
Tim Hoelter (Harley-Davidson)	Dave Oakleaf (D-37 AMA Off-Road DLO)
Mike Spencer	Rick Rothman (McCutchen, Doyle, et al.)
Bob Alsip (Suzuki)	Kerry Bryant (White Brothers)
Tom Austin (Sierra Research)	J.C. Delaney
Kevin Wood (Summit Industries)	David Raney (Honda)
John Paliwoda (CMDA)	David Koshork (DynaJet Research)
Mike Edmonton (Advanced Fuel Technologies)	Gary Higgins (Honda)
Wm (Red) Edmonton (Adv. Fuel Technologies)	Dana Bell (AMA)
Pamela Amette (MIC)	Harold Soens (AMA-D-38)
Edward Michel (Harley-Davidson)	Mark Boyer (Boyer Syndicate)
Lit-Mian Chan (EF & EE)	Bill Dart (AMA District 36)
Jerry Coker (CEE)	Tom Cates (K & N Eng.)