State of California
AIR RESOURCES BOARD

2006 Review of the 1998 Amendments to the California On-Road Motorcycle Regulations

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2006 REVIEW OF THE 1998 AMENDMENTS TO THE CALIFORNIA ON-ROAD MOTORCYCLE REGULATIONS

EXECUTIVE SUMMARY

In December 1998, the Air Resources Board (ARB or Board) adopted amendments to the California On-Road Motorcycle Regulations. The original (1975) regulations set hydrocarbon (HC) and carbon monoxide standards for all motorcycles with engine displacements of at least 50 cubic centimeters (cc). The 1998 amendments added control of oxides of nitrogen (NOx) to the regulations for the larger, Class 3 motorcycles (280 cc or greater). They set a Tier I standard of 1.4 grams per kilometer (g/km) HC+NOx beginning with 2004 models and a Tier II standard of 0.8 g/km HC+NOx beginning in 2008 for major manufacturers. The standards include corporate averaging provisions. For small volume manufacturers, the Tier I requirement begins with the 2008 model year, and there is no Tier II standard. Small volume manufacturers were defined in the final regulations as manufacturers with annual California sales of no more than 300 motorcycles.

The 1998 rulemaking specified a 2006 review on manufacturers' ability to meet the Tier I standard as well as an update on the progress being made toward meeting the Tier II standard. All major manufacturers were able to meet the Tier I standard by the 2004 model year as required. On average, motorcycles sold in California by major manufacturers in 2004 achieved emissions of 0.92 g/km HC+NOx, compared to the 2004 Tier I standard of 1.4 g/km HC+NOx. Analysis of sales data from 1998 to 2004 showed no significant increase in price for the complying 2004 models, and sales volumes of motorcycles from the major manufacturers have trended upward since 2002.

Major manufacturers continue to make progress towards meeting the 2008 Tier II standard. On average, major manufacturer motorcycles certified for sale in California in 2006 achieved emissions of 0.87 g/km HC+NOx. Major manufacturers are currently using fuel injection, oxidation catalysts, three-way catalysts, and/or various sensors to achieve this emission level.

The regulation gives the small volume manufacturers until 2008 to meet the Tier I standard. Until then, small volume manufacturers may continue to certify to the existing HC standard. In 2006, small volume manufacturer engine families that certified to HC+NOx, rather than to HC alone, achieved an average HC+NOx emission level of 0.92 g/km, only slightly higher than that achieved by the major manufacturers. Small volume manufacturers tend to use the same technologies as the major manufacturers to achieve these emission levels.

Tampering is a major concern for the on-road motorcycle fleet. According to industry surveys, one third of on-road motorcycles may be modified during or after purchase. Such modification may be considered tampering if the emission control systems are involved. Tampering may substantially increase emissions. Tampering would include removal of the catalytic converter or carbon canister, changing adjustable parameters or adding devices to boost horsepower. As more manufacturers include catalysts to reduce emissions (two thirds of Class 3 (larger) 2006 model year motorcycles), this becomes a greater issue. ARB is working with the motorcycle and motorcycle parts industries, Bureau of Automotive Repair, and others to address tampering. One way to address tampering is to require Smog Check for motorcycles. This is proposed in the 2007 State Implementation Plan (SIP). Once the tampering issue has been largely resolved through Smog Check and/or other means, current technologies provide an opportunity to further reduce exhaust and evaporative emissions from all motorcycles. Indeed, such reduction is a long-term measure that is also included in the draft 2007 SIP.

2006 REVIEW OF THE 1998 AMENDMENTS TO THE CALIFORNIA ON-ROAD MOTORCYCLE REGULATIONS

I. INTRODUCTION

In December 1998, the Air Resources Board (ARB or Board) adopted amendments to the California On-Road Motorcycle Regulations, first adopted in 1975 and amended in 1984. The original 1975 regulations set a hydrocarbon (HC) exhaust standard for all motorcycles with engine displacements of at least 50 cubic centimeters (cc). The 1984 amendments increased flexibility in the original regulations, allowing emission averaging across engine families. The 1998 amendments added control of oxides of nitrogen (NOx) to the regulations. Like the 1984 amendments, the 1998 amendments affected only Class 3 motorcycles (280 cc or greater).[1] They set a Tier I exhaust standard of 1.4 grams per kilometer (g/km) HC+NOx for 2004 models, and a Tier II exhaust standard of 0.8 g/km HC+NOx for 2008 models. The standards are applied as a corporate average, with no individual engine family exhaust emissions to exceed 2.5 g/km HC+NOx. For small volume manufacturers, the Tier I 1.4 g/km HC+NOx standard does not begin until the 2008 model year. Small volume manufacturers do not have to comply with the Tier II exhaust standard. Small volume manufacturers were defined in the final regulations as manufacturers with annual California sales of no more than 300 motorcycles of any displacement.[2]

During the development of the 1998 amendments, discussions with manufacturers and suppliers, together with a review of the 1998 ARB on-road motorcycle certification database, indicated that major manufacturers would have little difficulty meeting the 2004 Tier I standard. That standard was based on the widespread use of reasonably available and demonstrated engine modifications. Compliance with the 2008 standard was expected to be achieved with a combination of further engine modifications and additional use of aftertreatment such as catalytic converters. The corporate averaging provisions, however, allow some models to avoid use of a catalyst.

The Board requested a progress review in 2006 to evaluate the success, cost, and consumer acceptance of motorcycles meeting the 2004 standard, and to review manufacturers' efforts to meet the 2008 Tier II standard, which should be well

[1] Throughout this document, reference to motorcycle manufacturers, sales volumes, engine families, and emission averages, relate to only the Class 3 motorcycles with a displacement of 280 cc or more unless otherwise specified.

[2] As a condition of obtaining certification as a small volume manufacturer, the manufacturer shall submit annually to ARB's Executive Officer a summary of its efforts and progress toward meeting more stringent HC+NOx exhaust emission standard, including a description of the manufacturer's current HC+NOx emission control development status, along with supporting test data, and future planned development work.

underway at that point.[3] This report provides the requested review. It is divided into several sections. The first section reviews compliance with the Tier I standard. It shows that the major manufacturers met the 2004 requirements, and that consumers have been purchasing these cleaner motorcycles. The second section reviews progress made by all manufacturers to meet the 2008 requirements. It shows that both major and small volume manufacturers are on track to meet the 2008 requirements. The final sections address price and sales trends, tampering, and other issues.

II. MEETING THE TIER I STANDARD

About half of Class 3 engine families certified for the 1998 model year met or came close to meeting the 2004 Tier I standard at the time the regulations were adopted in December 1998. These engine families represented about 60 percent of the 1998 market. Those models not in compliance were expected to use the same technologies as those which were already complying. These technologies include fuel injection to replace carburetors, secondary pulse-air injection, and relatively simple changes to the engine timing, camshaft, valves, or combustion chambers. Nine of the 98 engine families certified for the 1998 model year used oxidation or three-way catalysts to comply with existing standards. This indicates that expanded use of catalysts was an option for at least a segment of the industry.

A. Major Manufacturers

The major manufacturers not meeting the proposed standard in 1998 were able to meet the standard by the 2004 model year as required. On average, motorcycles sold in California by major manufacturers in 2004 achieved emissions of 0.92 g/km HC+NOx compared to the 2004 Tier I standard of 1.4 g/km HC+NOx. Analyses presented in the Staff Report for the 1998 amendments suggested a projected sales-weighted average cost increase for the entire industry of about $44 per motorcycle. An analysis of the motorcycle price trends from 1998 to 2004 shows no unusual price increase for 2004 models, and sales volumes have been on an upward trend. (See Section IV.)

B. Small Volume Manufacturers

The small volume manufacturers continue to make progress towards meeting their regulatory requirement. Small volume manufacturers account for about four percent of Class 3 motorcycle sales. Given the potentially lower amount of development dollars available to these smaller firms, the regulations give the small volume manufacturer until 2008 to meet the Tier I standard. This additional time allows those manufacturers to use off-the-shelf technology to achieve required emission levels. Small volume manufacturers opted to certify about one third of total engine

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[3] The Resolution language directs ARB's Executive Officer to "conduct a progress and cost review, prior to December 31, 2006, of the on-road motorcycle manufacturers' efforts to meet the first and second tier standard set forth in Attachment A". Discussion at the Board hearing, as reflected by the official transcript, indicates that this review can be utilized to determine if the small volume manufacturers should be required to comply with Tier II requirements in the future.

families to a HC+NOx emission standard rather than a HC only emission standard in 2004.[4] The sales-weighted average emission level achieved was 1.13 g/km HC+NOx. Engine families certifying to the HC standard for small volume manufacturers achieved a sales-weighted average of 0.67 g/km HC.[5] Based on discussions with manufacturers in 1998, typical NOx levels for motorcycles at that time ranged from 0.5 to 0.7 g/km. Therefore, assuming that changes made to reduce HC emissions will not exceed an upper level of 0.7 g/km NOx, these motorcycles should be able to comply, on average, with the Tier I standard required of small volume manufacturers in 2008.[6]

III. MEETING THE TIER II STANDARD

Technologies identified in the 1998 Staff Report as likely to be used to meet the Tier II standard included electronic fuel injection, precise air to fuel ratio controls, programmed secondary pulse air injection, low thermal capacity exhaust pipes, and two- or three-way catalysts. Discussions with the Motorcycle Industry Council (MIC) in 1998 indicated that achieving levels of 0.9 g/km HC+NOx was feasible without the wide-spread use of catalysts. To meet the Tier II standard with a comfortable compliance margin would require an additional 33 percent reduction in HC+NOx emissions. This reduction is well within the capabilities of existing three-way catalysts, which, in 1998, had already been shown to achieve a 60-85 percent reduction in HC and NOx emissions. Due to the high emission reduction capability of three-way catalysts, ARB anticipated that manufacturers would 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.

A. Major Manufacturers

Major manufacturers continue to make progress towards meeting the 2008 Tier II standard. On average, major manufacturer motorcycles certified for sale in California in 2006 achieved emissions of 0.87 g/km HC+NOx. Major manufacturers are currently using fuel injection, oxidation catalysts, three-way catalysts, and/or various sensors to achieve this emission level. For example, three quarters of 2006 models use fuel injection, and two thirds use catalysts. These same technologies are expected to be used to comply with the Tier II standard and were estimated in the 1998 Staff Report to cost (on a corporate average basis) less than $100 per motorcycle.

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[4] While the applicable standard for the small volume manufacturers continues to be "HC only" until 2008, HC+NOx emissions are clearly higher than HC only, so it is acceptable to certify motorcycle engines in this way. This choice may have been made by some manufacturers to acquire credits, or it may be due to sales volumes that hover around the small volume manufacturer cut-off.

[5] Five manufacturers submitted both HC and HC+NOx figures. All submitted figures were used in calculating the sales-weighted averages.

[6] 0.67 g/km HC plus 0.7 g/km NOx (1.37 g/km HC+NOx)

B. Small Volume Manufacturers

While small volume manufacturers are not currently subject to the Tier II standard, indications from the certification database are that most would be able to comply with the standard in the future. In fact, of those engine families certified in the 2006 model year to the HC+NOx standard, the average emission levels were 0.92 g/km HC+NOx, only slightly above that seen for the major manufacturers. The use of improved fuel delivery and aftertreatment such as catalysts would likely reduce emissions from most small volume manufacturers to the Tier II levels at a cost similar to that for major manufacturers.

C. Analyses of 2006 Models

Staff examined the 2006 certification database for on-road motorcycle engine families. Thirteen major manufacturers certified 115 engine families in 2006, while 41 small volume manufacturers certified 66 engine families. Projected sales were 92,916 Class 3 motorcycle engines in 2006. Major manufacturers produced slightly over 96 percent of the total motorcycles sold, with 89,307 total projected sales. Manufacturers of Class 3 engines are listed in Tables 1 and 3. Further data for these motorcycles are provided in the Appendices.

1. Major Manufacturers

Emissions for major manufacturers ranged from 0.2-2.1 g/km HC+NOx, with a sales-weighted average of 0.87 g/km HC+NOx, well below the 1.4 g/km standard. This sales-weighted average is only slightly above the 2008 Tier II standard of 0.80 g/km HC+NOx. In fact, 59 out of the 115 engine families certified by major manufacturers have certified emissions at or below the 2008 Tier II standard. These 59 engine families represented 47 percent of the total engine sales by major manufacturers. Most of the major manufacturers appear to be on track to comply with the 2008 Tier II standard.

The 2006 model year corporate average emissions[7] for major manufacturers are summarized in Table 1. The **bolded** figures in the table indicate average certified emissions at or below the 2008 Tier II standard. Further details on the progress of each manufacturer are included in the Appendices.

The cleaner engine families typically, although not always, utilized a catalyst. Most were fuel injected rather than carbureted. Table 2 presents the percentage of engine families using specified technologies as well as the sales-weighted figures. Note that multiple technologies may be used, so that the totals add up to more than 100 percent. As anticipated in ARB's 1998 Staff Report, most manufacturers have replaced the carburetor with a fuel injection system, and utilized a catalyst. Pulse air injection has also become common. Various engine modifications have also been employed, such as relatively simple changes to the engine timing, camshaft, valves, or combustion chambers, and more involved engine redesign.

[7] This corporate average was determined by summing the product of sales and emissions for each engine family, divided by total sales for that manufacturer.

Table 1. 2006 Model Year Emissions by Major Manufacturers

Manufacturer	HC+NOx range	Avg HC+NOx
Am. Ironhorse	1.25	1.25
BMW	0.22-0.98	**0.44**
Buell	0.80-1.07	0.87
Ducati	0.47-1.33	**0.75**
Harley Davidson	0.75-1.71	1.07
Honda	0.3-1.2	**0.79**
Hyosung	1.16	1.16
Kawasaki	0.4-1.6	0.84
Suzuki	0.24-1.49	0.83
Thunder Mtn	1.00	1.00
Triumph	0.22-1.98	**0.53**
Victory	0.75-1.06	1.05
Yamaha	0.2-2.1	0.86
Total Sales	0.2-2.1	0.87

Table 2. Technologies used to Reduce Emissions, 2006 Model Year

Technology	Engine Families	Sales
Three-Way Catalyst	30%	24%
Oxidation Catalyst	37%	45%
Oxygen Sensor	29%	23%
Pulse Air Injection	67%	50%
Fuel Injection	73%	67%

2. Small Volume Manufacturers

For the small volume manufacturers, 44 out of 66 engine families opted to certify HC+NOx emissions in 2006. The rest certified to the HC standard which is available to small volume manufacturers until 2008. Sales-weighted average certified emissions were 0.92 g/km HC+NOx. Table 3 shows corporate average HC+NOx emissions for the small volume manufacturers who chose to certify at least one engine family to HC+NOx. As shown, all engine families have emissions sufficiently low to meet the 2008 1.4 g/km HC+NOx standard for small volume manufacturers. Again, the **bolded** figures in the table indicate small volume manufacturers that have average certified emissions at or below the Tier II standard required to be met by major manufacturers in 2008. Eleven engine families, representing about 18 percent of the small volume manufacturer total sales, reported levels at or below 0.8 g/km HC+NOx. Engine families certified at higher emission levels (above 1 g/km

HC+NOx) were predominantly carbureted, while about half of those that could meet or were approaching the Tier II standard were also carbureted. The lower emitting families typically used some form of catalyst, while the higher emitters tended to use only engine modifications. Given that most of the higher emitting engine families lacked any significant engine-out or aftertreatment controls, it is reasonable to assume that with such controls, which typically reduce "tail-pipe" emissions by 60 percent or more, these remaining manufacturers could meet a Tier II standard. Note that these small volume manufacturers are only required to comply with the Tier I standard for 2008, however. Requiring small volume manufacturers to meet the Tier II standard in the future would result in an emissions benefit of approximately 0.1 tons HC+NOx per summer day, a relatively small reduction in emissions.

Table 3. Average Emissions, Small Volume Manufacturers, 2006 Model Year

Manufacturer	HC+NOx	Manufacturer	HC+NOx	Manufacturer	HC+NOx
Am. Perf	1.18	Illusion	0.98	Rucker	1.22
Aprilia	0.86	KTM Sport	**0.63**	Saxon	1.01
Big Bear	1.13	Moto Guzzi	0.91	Swift	1.01
Big Dog	1.05	MV Agusta	**0.53**	TP Eng.	1.20
Bourgets	0.92	Ness	1.02	Ultima	0.99
Bimota	0.94	Piaggio	**0.64**	Ultra	1.20
Eicher Int'l	1.11	Power Auto	**0.8**	Von Dutch	1.23
Hard Bikes	1.15	Pro-One	0.97	West Coast	0.9
Hellbound	1.17	Proper Chop.	0.99	Westward	**0.05**

The remaining 22 of the 66 engine families offered for sale by small volume manufacturers certified to the HC standard for the 2006 model year. Hydrocarbon values ranged from 0.11 to 1.14 g/km, with a sales-weighted average of 0.74 g/km HC. Given that NOx values were previously reported to range from 0.5 to 0.7 g/km for pre-1998 regulation motorcycles,[8] it is likely that most, if not all, small volume manufacturers currently certifying to the HC standard will be able to meet the Tier I HC+NOx standard required of small volume manufacturers in 2008 with little additional effort. Additional details for small volume manufacturer engine families may be found in Appendix C.

D. Emission Trends

Emission trends from 2002 to present are shown in Table 4 below. Since the Tier I standard became effective in the 2004 model year, the major manufacturers have shown a decrease in average emissions of about five percent. The small volume manufacturers opting to certify to the HC+NOx standard have shown emission reductions on the order of 19 percent for HC+NOx since 2004.

[8] For 2004 model year motorcycles, average NOx levels are less than in 1998 (i.e., an analysis of those engine families reporting both HC and HC+NOx values in 2004 shows an average of 0.4 g/km NOx, with a range of 0.1 to 0.8 g/km NOx.)

Table 4. Model Year 2002-2006 Emissions Trends

	Major Manufacturers		Small Volume Manufacturers	
Model Yr	HC	HC+NOx	HC	HC+NOx
2002	0.72 (94 fam)*	--	0.76 (28 fam)	--
2003	0.87 (92 fam)	--	0.74 (40 fam)	--
2004	--	0.92 (95 fam)	0.67 (30 fam)**	1.13 (13 fam)
2005	--	0.86 (121 fam)	0.76 (36 fam)	1.07 (19 fam)
2006	--	0.87 (115 fam)	0.74 (22 fam)	0.92 (44 fam)

* Emissions in g/km (number of engine families included in the calculation)
** See footnote 5

Based on analyses presented above, it is reasonable to assume that further emission reductions, as suggested in the draft 2007 State Implementation Plan (SIP), are feasible for on-road motorcycles. Future standards could be based on greater use of catalysts, and a substantial reduction, or possibly elimination, of corporate emission averaging provisions.

IV. PRICE AND SALES TRENDS

Staff researched the prices charged for motorcycles from 1998 to the present. Two methods were used. In the first approach, staff accessed the Department of Motor Vehicles (DMV) database, which includes the price paid for vehicles registered in California between 1998 when the regulation was adopted through 2004 when Tier I became effective. Figure 1 shows a slight upward trend in the price of motorcycles, as would be expected due to general cost-of-living increases and enhancements in the basic motorcycle package, but no peak was apparent reflecting increased prices for the 2004 model year. Between 2003 and 2004, average prices actually decreased.[9]

In the second approach, to look beyond 2004, staff accessed the internet to ascertain manufacturer's suggested retail price (MSRP) for eleven motorcycle models powered by engine families with high anticipated sales volumes in 2006[10]. A specific model was selected based on preliminary indications of the likelihood of MSRP information. An attempt was made to gather this information for the 1998 to 2007 timeframe. However, models change over the years, and staff was unable to find and/or validate the MSRP for all years of interest. However, prices were fully

[9] The DMV database does not include an identifier as to whether a motorcycle sold was new or used. To minimize the chance of including used motorcycles in the analysis, values were included from the start of each model year through December 31 of each model year. In addition, the DMV database contains a number of blank fields or fields filled with a default value (e.g., a price of $99,999). These were eliminated from the analysis.
[10] Internet sites offering price information included motorcycle.about.com, motorworld.com, motorcycle.com, motorcyclecruiser.com, and motorcycle-usa.com.

Figure 1. Sales Price Trends, DMV Database

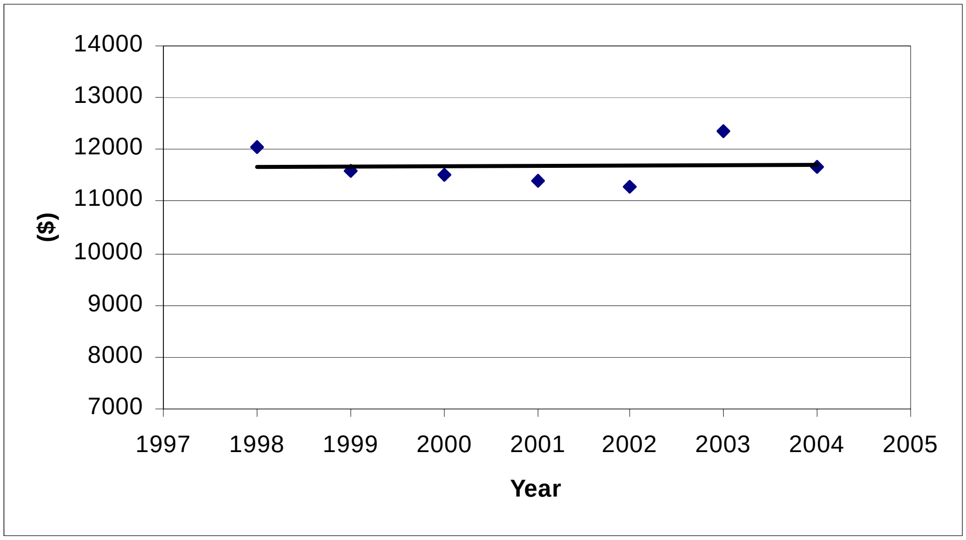
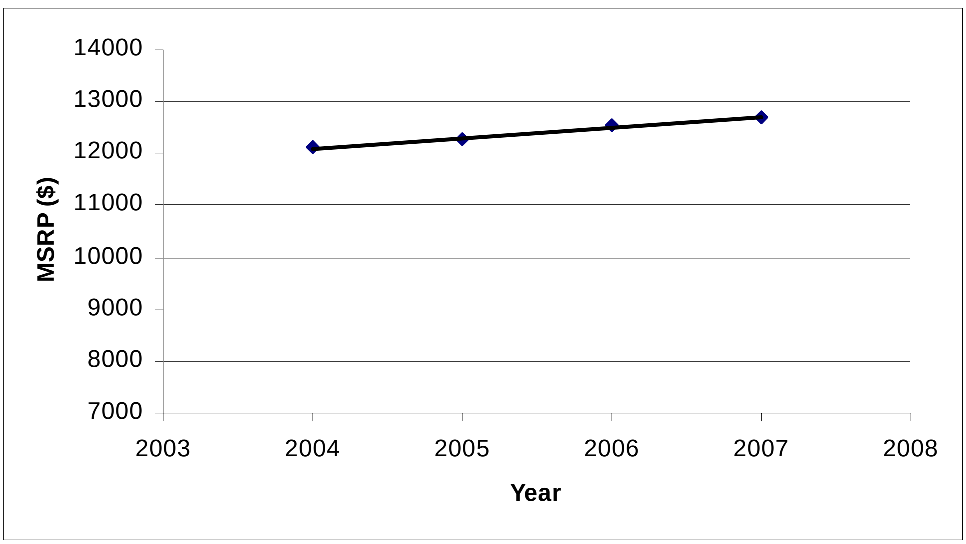


Figure 2. Manufacturer's Suggested Retail Price, 2004-2007



available in the 2004-2007 timeframe. For 2006, prices for the eleven models ranged from $6,595 to $17,995. The engine family sales-weighted averages are presented in Figure 2.[11] This figure shows no unusual price increases to date even though the use of catalysts on motorcycles has increased significantly over this time period (see Table 6).

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[11] The annual average price for the eleven models selected reflects the engine family sales weighting, not necessarily the model sales weighting.

Sales trends represent a way to determine if price increases have adversely affected sales, thus slowing the introduction of new technology. Staff looked at sales figures from the 2002-2006 certification databases to examine trends before and after implementation of the Tier I standard. The sales figures are shown in Table 5 below. As can be seen, the overall trend shows increasing sales over these five years. The 2003 peak is likely due to pre-buying before the 2004 standard took effect. The low sales figures from 2005 may reflect the fact that 2005 was a year of exceptionally high rainfall in Southern California.

Table 5. Sales trends, 2002-2006

MY	Total Class 3 Sales	Large Volume Manufacturers	Small Volume Manufacturers
2002	59,915	58,942 (14 mfg)*	973 (14 mfg)
2003	80,887	78,333 (11 mfg)	2,554 (28 mfg)
2004	73,124	70,540 (11 mfg)	2,584 (26 mfg)
2005	72,373	69,387 (13 mfg)	2,986 (37 mfg)
2006	92,916	89,307 (13 mfg)	3,609 (41 mfg)

* projected sales from certification database (number of manufacturers)

V. TAMPERING

A. Sources of Tampering

ARB currently requires that emission control systems be “tamperproof”. This means that the vehicle owner cannot adjust emissions-related parameters (such as air and fuel jet screws for carbureted units, ignition timing, and turbocharger wastegate adjustments). The manufacturer is responsible for emission compliance on any emissions-related adjustable parameters for the full adjustment range.

During the development of the 1998 regulations, industry raised concerns about consumer tampering, especially for motorcycles using exhaust system catalysts. The MIC performs customer surveys every 5 years. As part of those surveys, MIC asks if the original exhaust system or muffler has been modified or replaced.[12] The 2003 survey indicated that almost 38 percent of exhaust systems had been modified or replaced for on-road motorcycles[13] nationwide, a rate comparable to that found in the 1998 survey. Replacements due to wear likely will not fall into the purview of tampering. However, those replacements made in an effort to increase power, to change or to increase the sound, and for styling may fall under the tampering provisions. Different types of motorcycles have substantially different rates of

[12] It is important to note that system replacement does not necessarily mean tampering. If the replacement system is functionally equivalent to the original, and/or if it has been demonstrated to ARB that the replacement system does not adversely affect emissions, then the replacement is not tampering. However, many replacements would likely fall under the tampering provisions for those motorcycles equipped with catalysts.

[13] All classes of on-road motorcycles were included in this survey.

exhaust system replacement, with cruisers and sports bikes having about twice the modification or replacement rate of traditional or touring motorcycles. Other frequently cited types of tampering include removal of the carbon canister, usually to make room for an accessory, and modifications to the fuel system in an attempt to increase horsepower.

B. Effect of Tampering

Tampering offsets some of the expected emission benefits to be gained by complying with the emission standards. Industry argued during the 1998 rulemaking that the Tier II standard would have much less benefit than projected, as meeting the Tier II standard was anticipated to require catalysts, and these catalysts would likely be removed if consumers changed the exhaust system. Indeed, as shown in Table 6, most of the engine families certified in 2006 did utilize catalysts as part of the strategy to achieve low emissions. However, a catalyst is not required to meet the Tier II standard. Of the engine families certified in 2006 with emissions at or below the 2008 Tier II standard, 14 percent do not use a catalyst (8 out of 59 families; see Appendix C). Further, the use of fleet averages means that all engines sold need not achieve the Tier II standard of 0.8 g/km HC+NOx. For instance, 64 percent of the engines sold by Honda in 2006 utilized a catalyst (See Table A-5). The average emissions for those engines were 0.53 g/km HC+NOx. Honda combined those with additional, higher emitting, motorcycle sales and achieved a total fleet average of 0.79 g/km HC+NOx, which would meet the 2008 requirements. The corporate averaging provision enables manufacturers to not apply catalysts to motorcycles they believe more likely to be impacted by tampering.

ARB does not know the extent of tampering with catalysts as of yet, but plans a study now that a substantial number of motorcycles in the fleet are certified with catalysts. The presence of catalysts on over half of new motorcycles sold, and the popularity of exhaust system replacement, suggests tampering should remain a concern.

C. Ways to Reduce Tampering or the Effect of Tampering

One way to reduce the effect of tampering is to fully utilize the corporate averaging provisions. If the manufacturers are cognizant of the models of motorcycles most likely to be subject to tampering by changes to non-approved exhaust systems, for example, they could choose to certify those engines at a higher emission level

Table 6. Overall Catalyst Use Rates for Model Years 2002 to 2006

MY	% Catalyst
2002	39%
2003	38%
2004	56%
2005	62%
2006	68%

utilizing technology such as secondary pulse air injection and fuel injection, reserving the use of catalysts for the motorcycles less likely to be subject to exhaust system tampering. Using corporate averaging, about 40 percent of motorcycles could remain at Tier I levels if the remainder were to use catalysts to certify at 0.4 g/km HC+NOx or thereabouts.

ARB met with motorcycle industry representatives on November 30, 2006, to discuss certification, tampering and other issues. Most attendees were small volume and aftermarket manufacturers, although Harley Davidson was also present. Industry representatives were asked to provide input as to types of tampering, effect of tampering, and ways to minimize the effect of tampering. ARB staff will utilize the information provided from this and other industry contacts to develop an approach to quantify the amount and effect of tampering and to determine strategies to minimize tampering and its effects. Concepts to consider include notification of dealers and repair shops of anti-tampering requirements,[14] on-going manufacturer education, rider education, dealer enforcement, enforcement on sales of aftermarket devices not certified through the Vehicle Code Section 27156 provisions,[15] and bringing motorcycles into the Smog Check system, as has been proposed in the 2007 SIP. Smog Check would require owners to undergo (at a minimum) a visual inspection of a motorcycle's emission control system to minimize tampering. The Smog Check program has significantly reduced tampering in the on-road automobile fleet, and could have similar results for the on-road motorcycle fleet as well.[16] When these or other measures have successfully and substantially reduced tampering rates, then further emission reductions can be adopted for on-road motorcycles. Such new standards would likely rely on more wide-spread application of catalysts.

VI. UNITED STATES ENVIRONMENTAL PROTECTION AGENCY ADVISORY LETTER

On July 25, 2006, the United States Environmental Protection Agency (U.S. EPA) issued a letter to manufacturers entitled "Certification Procedure for Highway Motorcycle Engines". In this advisory, U.S. EPA determined that it would allow motorcycle engines to be certified on an engine basis rather than a chassis basis if the certification is based on a "worst-case" chassis assumption. The intended beneficiaries are independent engine manufacturers, very small custom motorcycle manufacturers, and individuals wanting to build kit motorcycles. The objective was to enable small volume manufacturers to easily utilize engines

[14] The Bureau of Automotive Repair is planning to send out an informative letter.
[15] Essentially, this is an Executive Order from ARB certifying that the part does not result in an increase in emissions.
[16] The 2007 SIP includes a measure to require some form of Smog Check to help reduce excess motorcycle emissions. This measure is expected to result in a 2.6 ton per day reduction in reactive organic gases plus NOx in the South Coast Air Basin alone. These benefits are based on an inspection program less stringent than the current program for gasoline cars and trucks, and assume 50 percent of the reduction in emissions of the current enhanced Smog Check program. The SIP calls for this to be developed in the 2007/2008 timeframe, and to be implemented in 2010.

manufactured by major manufacturers in these small volume motorcycles. The manufacturer must also install the appropriate certified fuel lines and fuel tank, and any emission control equipment that was part of the original engine certification. Responsibility for emissions compliance is shifted from the engine manufacturer to the motorcycle manufacturer, provided the motorcycle manufacturer/assembler has followed the required provisions.

ARB also has a program to allow small volume motorcycle builders to enter into agreements wherein a supplying manufacturer provides the certified components for installation into custom motorcycles. The engine manufacturer must provide a comprehensive list of all the on-highway motorcycle models into which its engines may be installed, and the engine is installed and tested in the “worst case” situation. Unlike the U.S. EPA’s program, ARB requires that the supplying manufacturer continue to accept responsibility for warranty and exhaust and evaporative compliance. (This is Option 3 in ARB’s on-road motorcycle certification procedures, reiterated at the November 30, 2006 meeting with motorcycle representatives.) An individual builder in California who constructs a motorcycle for personal use may register it under the specialty construction vehicle provisions. ARB currently does not have plans to adopt the U.S. EPA’s provisions due to concerns about compliance responsibility and the fact that whereas the U.S. EPA regulations include exhaust emissions and calculated permeation values for hoses and fuel tanks, ARB’s emission requirements also require that a motorcycle undergo SHED (Sealed Housing Evaporative Determination) testing to determine actual evaporative emissions. However, ARB plans to continue to meet with manufacturers to clarify how they can fully utilize available provisions in the regulations.

VII. CONCLUSIONS

ARB staff concludes that:

1. Compliance by major Class 3 motorcycle manufacturers with the Tier I emission standard has been successful. A full range of models is available, and sales have continued to grow through 2006. Analyses show prices have been largely constant from 1998 through 2004, revealing no price spike when the 2004 model year Tier I standard went into effect. Sales have continued to trend upward.
2. Compliance by major Class 3 motorcycle manufacturers with the Tier II emission standard that goes into effect with 2008 models is also feasible. The 2006 average emissions are 0.87 g/km HC+NOx, close to the 0.80 g/km 2008 standard. Additional use of catalysts and engine modifications should assure all models comply with the required fleet average. Prices have increased since 2004, but the increases do not appear to have adversely impacted sales.
3. Most models offered by small volume manufacturers, who account for about four percent of sales, have emissions low enough to comply with the Tier I standard, which goes into effect with 2008 models. Further controls, such as

catalysts, are available to reduce emissions from models that currently exceed the forthcoming standard.

4. The average emissions of small volume manufacturer models certifying to HC+NOx (one third of all small volume models) is 0.92 g/km, only slightly higher than the average for major manufacturers. The emission benefit of requiring motorcycles certified by small volume manufacturers to comply with the Tier II standard that currently applies only to major manufacturers is 0.1 tons HC+NOx per summer day with full market penetration. It is not considered worthwhile at this time to amend the regulation simply to require these relatively few motorcycles (less than 4000 per year) to comply with a Tier II standard. However, the 2007 SIP does suggest that for the long term, more stringent exhaust and evaporative requirements be adopted for all on-road motorcycles. Requiring small volume manufacturers to comply with the Tier II standard should be incorporated into that effort.
5. Staff has not yet determined the frequency of tampering on motorcycles. The presence of catalysts on over half of new motorcycles sold, and the popularity of exhaust system replacement, suggests tampering should remain a concern. Staff plans to determine the rate of tampering this year, and will report to the Board the results, with any recommendations if appropriate.
6. The 2007 State Implementation Plan includes a proposed measure to require some form of Smog Check inspection to help reduce excess motorcycle emissions. This measure is expected to result in a 2.6 ton per day reduction in reactive organic gases plus NOx in the South Coast Air Basin alone. These benefits are based on an inspection program less stringent than the current program for gasoline cars and trucks, and assume 50 percent of the reduction in emissions of the current enhanced Smog Check program. The SIP calls for this to be developed in the 2007/2008 timeframe, and to be implemented in 2010.
7. Lower exhaust standards that rely on the wide-spread use of catalysts are feasible and could be adopted. This would be consistent with the draft 2007 SIP, which suggests that for the long term, more stringent exhaust and evaporative requirements be adopted for all on-road motorcycles.

Appendix A

A. Details of the 2004 Certification Database

Staff examined the 2004 certification database for on-road motorcycles. For the Class 3 sector, 11 major manufacturers certified 109 engine families and 27 small volume manufacturers certified 38 engine families, with total projected sales of 73,124 motorcycles (70,540 from major manufacturers and 2,584 produced by small volume manufacturers). Major manufacturers produced about 96.5 percent of the total motorcycles sold. The major manufacturers of Class 3 engines for the 2004 model year are listed in Table A-1.

Emissions from these engine families ranged from 0.2-2.5 g/km HC+NOx,[17] with a sales-weighted average of 0.92 g/km HC+NOx, well within the 1.4 g/km standard. Indeed, 45 of the 109 engine families certified by major manufacturers certified emissions at levels less than or equal to 0.8 g/km HC+NOx.[18] These lower emitting engine families typically, although not always, utilized an oxidation or three-way catalyst. The 45 engine families include engines manufactured by Aprilia, BMW, Ducati, Harley Davidson, Honda, Kawasaki, Suzuki, Triumph, and Yamaha. Summary details are available in Table A-1.

For the small volume manufacturers, 13 engine families representing 53 percent of the total Class 3 sales by small volume manufacturers certified to HC+NOx, with a range of 0.86 to 1.31 g/km HC+NOx. By 2004, these engine families have certified emissions at levels less than the 2008 standard for small volume manufacturers of 1.4 g/km HC+NOx. The majority of engine families offered for sale by small volume manufacturers certified to the HC standard for the 2004 model year, with a sales-weighted average of 0.67 g/km HC. Given typical HC to NOx ratios, one would expect that most of these engine families would meet the 2008 standard for small volume manufacturers by 2004.

B. Details of the 2005 Certification Database

Staff examined the 2005 certification database for on-road motorcycle engine families. Thirteen major manufacturers certified 123 Class 3 engine families and 37 small volume manufacturers certified 55 Class 3 motorcycle engine families, with total projected sales of 72,373 motorcycles (69,387 from major manufacturers and 2,986 produced by small volume manufacturers). Major manufacturers produced almost 96 percent of the total Class 3 motorcycles sold. The 2005 model year major manufacturers are listed in Table A-2.

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[17] While the Tier I standard is 1.4 g/km HC+NOx, corporate averaging allows an engine family to be certified to a maximum of 2.5 g/km HC+NOx.

[18] Emissions equal to or less than 0.8 g/km HC+NOx are considered in these analyses to be at a Tier II level. When certifying emissions, manufacturers include a compliance margin. Thus, the manufacturers would be desirous of achieving emissions 20-30 percent below the standard, probably around 0.6 g/km HC+NOx. However, the value submitted to the certification database already includes this margin.

Table A-1. Summary of 2004 Certification Data for Major Manufacturers

MFR	HC+NOx*	#T2fam/tot	#catFam/tot	%T2sales	%catSales	%T2catSales	T2 flt avg	cat flt avg
Aprilia	0.83	3/7	4/7	39%	54%	100%	0.52	0.64
Big Dog	1.16	0/3	0/3	n/a	n/a	n/a	n/a	n/a
BMW	0.95	2/4	3/5	23%	72%	75%	0.68	0.92
Ducati	0.92	1/6	3/7	27%	56%	100%	0.67	0.84
Harley	0.87	5/8	5/8	85%	67%	73%	0.78	0.79
Honda	0.95	6/18	11/19	43%	72%	95%	0.58	0.75
Kawasaki	1.04	9/17	12/22	49%	45%	100%	0.67	0.69
Suzuki	0.92	14/18	15/21	60%	54%	57%	0.62	0.87
Triumph	0.88	2/6	4/7	61%	60%	76%	0.71	0.88
Victory	0.885	0/1	1/1	0%	100%	0%	n/a	0.885
Yamaha	0.91	3/7	7/9	56%	70%	74%	0.65	0.93
OVERALL	0.92	45/95	65/109	61%	63%	56%	0.72	0.8

*Several engine families provided only HC emissions data for 2004.

Key: "MFG" is manufacturer; "#T2fam/tot" is the number of engine families certified at or below 0.8 g/km HC+NOx / total number of certified families by that manufacturer; "#catFam/tot" is the number of engine families who reported using a catalyst as part of the emission control strategy / total number of certified families by that manufacturer; "%T2sales" is the percentage of total engines with certified emissions less than or equal to the Tier II standard projected to be sold; "%catSales" is the percentage of total engines utilizing a catalyst as part of the emission control strategy; "%T2catSales" is the percentage of those motorcycles with certified emissions at or below 0.8 g/km HC+NOx that utilized a catalyst as part of the emission control strategy; "T2 flt avg" is the sales-weighted average emissions of those engines with certified emissions at or below 0.8 g/km HC+NOx; and "cat flt avg" is the sales-weighted average emissions of those engine using a catalyst as part of the emission control strategy.

Table A-2. Summary of 2005 Certification Data for Major Manufacturers

MFR	HC+NOX	#T2fam/tot	#catFam/tot	%T2sales	%catSales	%T2catSales	T2 flt avg	Cat flt avg
Aprilia	0.74	3/5	5/5	61%	100%	100%	0.56	0.74
Big Dog	0.9	0/1	0/1	0%	0%	n/a	n/a	n/a
Buell	1.2	0/2	0/2	0%	0%	n/a	n/a	n/a
BMW	0.6	8/9	9/9	91%	100%	100%	0.54	0.6
Ducati	1.03	2/5	4/7	31%	55%	100%	0.69	0.83
Harley D	0.86	3/7	5/7	82%	96%	100%	0.75	0.84
Honda	0.76	16/20	13/20	64%	69%	90%	0.57	0.63
Kawasaki	0.88	11/21	15/21	50%	73%	67%	0.69	0.87
Piaggio*	0.64	1/1	1/1	100%	100%	100%	0.64	0.64
Suzuki	1.09	7/24	11/24	11%	39%	78%	0.7	1.01
Triumph	0.97	2/10	7/10	21%	61%	100%	0.34	0.77
Victory	0.83	1/2	1/2	85%	85%	100%	0.75	0.75
Yamaha	0.86	6/13	7/13	71%	76%	100%	0.65	0.67
OVERALL	0.86	60/121	79/123	60%	62%	96%	0.67	0.58

*Piaggio is a major manufacturer in 2005 due to its combined Class 1, 2, & 3 engine sales.

Key: See Table A-1 Key above.

Emissions ranged from 0.2-2.1 g/km HC+NOx, with a sales-weighted average of 0.86 g/km HC+NOx, well within the 1.4 g/km standard, and slightly reduced from the 2004 average. Sixty out of the 123 engine families certified by major manufacturers certified emissions at levels less than or equal to the 2008 Tier II standard by 2005. These families represent 60 percent of the total projected sales, and typically, although not always, utilized an oxidation or three-way catalyst. Summary data are available in Table A-2.

For the small volume manufacturers, 19 engine families were certified to the HC+NOx standard, with a sales-weighted average of 1.07 g/km HC+NOx. Most of these engine families have certified emissions at levels less than or equal to the 2008 standard for small volume manufacturers of 1.4 g/km HC+NOx. These 19 engine families represent almost 40 percent of units sold by small volume manufacturers. The majority of engine families offered for sale by small volume manufacturers certified to the HC standard for the 2005 model year, with a sales-weighted average of 0.76 g/km HC. Given typical HC to NOx ratios, one would expect that most, if not all, engine families would meet the 2008 standard for small volume manufacturers.

C. Additional Details of the 2006 Certification Database

Table A-3 provides a summary of the 2006 data regarding certified emission levels and catalyst use. Table A-4 illuminates the emission trends by manufacturer. For most manufacturers, the trend has been for the sales-weighted fleet average to decline.

Table A-3. Summary of 2006 Certification Data for Major Manufacturers

MFR	HC+NOX	#T2fam/ttl	#catFam/ttl	%T2sales	%catSales	%T2catSales	T2 flt avg	Cat flt avg
Am.Irnhrs.	1.25	0/1	0/1	0%	n/a	n/a	n/a	n/a
BMW	0.43	6/7	7/7	89%	100%	100%	0.37	0.43
Buell	0.87	0/2	0/2	n/a	n/a	n/a	n/a	n/a
Ducati	0.75	5/9	6/9	89%	84%	91%	0.69	0.7
Harley D	1.07	1/8	4/8	24%	59%	100%	0.75	0.92
Honda	0.79	15/20	14/20	51%	64%	86%	0.53	0.65
Hyosung	1.16	0/2	0/2	n/a	n/a	n/a	n/a	n/a
Kawasaki	0.84	12/21	16/21	53%	76%	74%	0.67	0.79
Suzuki	0.8	7/20	12/20	61%	58%	58%	0.6	0.75
Thunder M	1	0/1	0/1	n/a	n/a	n/a	n/a	n/a
Triumph	0.53	3/7	6/7	72%	95%	100%	0.31	0.45
Victory	1.05	1/2	2/2	3%	100%	100%	0.75	1.05
Yamaha	0.86	9/15	10/15	70%	75%	100%	0.57	0.6
OVERALL	0.87	59/115	77/115	47%	68%	96%	0.57	0.72

Key: See Key for Table A-1

Table A-4. Summary of Emission Trends by Major Manufacturer

	Fleet Average			Tier II Fleet Average*			Catalyzed Fleet Average*		
Manufacturer	2004	2005	2006	2004	2005	2006	2004	2005	2006
Aprilia	0.83	0.74	--	0.52	0.56	--	0.64	0.74	--
BMW	0.95	0.6	0.43	0.68	0.54	0.37	0.92	0.6	0.43
Ducati	0.92	1.03	0.75	0.67	0.69	0.69	0.84	0.83	0.7
Honda	0.95	0.76	0.79	0.58	0.57	0.53	0.75	0.63	0.65
Kawasaki	1.04	0.88	0.84	0.67	0.69	0.67	0.69	0.87	0.79
Suzuki	0.92	1.09	0.8	0.62	0.7	0.6	0.87	1.01	0.75
Triumph	0.88	0.97	0.53	0.71	0.34	0.31	0.88	0.77	0.45
Victory	0.88	0.86	1.05	--	0.75	0.75	0.88	0.75	1.05
Yamaha	0.91	0.86	0.86	0.65	0.65	0.57	0.93	0.67	0.6
Harley D	0.87	0.86	1.07	0.78	0.75	0.75	0.79	0.84	0.92
Overall	0.92	0.86	0.87	0.72	0.67	0.57	0.8	0.67	0.72

* The Tier II fleet average is the sales-weighted average of those engine families that had certified emissions at or below 0.8 g/km HC+NOx. The catalyzed fleet average is the sales-weighted fleet average for engine families that utilized a catalyst as part of their emission control strategy. These engine families each may or may not have achieved emission levels of 0.8 g/km HC+NOx or below.

Table A-5 shows the sales-based percentage of engine families that use catalysts, and the sales-based percentage of those engine families with emissions less than the Tier II standard that utilized a catalyst. The use of fleet averages means that all engines sold need not achieve the Tier II standard. For instance, 64 percent of the engines sold by Honda in 2006 utilized a catalyst, achieving average emissions of 0.53 g/km HC+NOx. Honda combined those with additional, higher emitting, motorcycles and achieved a total fleet average of 0.79 g/km HC+NOx.

Table A-5. Sales-Based Catalyst Use Rates, 2004-2006

	MY 2004		MY 2005		MY 2006	
Manufacturer*	% Cat	% T2 Cat	% Cat	% T2 Cat	% Cat	% T2 Cat
BMW	72%	75%	100%	100%	100%	100%
Ducati	56%	100%	55%	100%	84%	91%
Harley Dav.	67%	73%	96%	100%	59%	100%
Honda	72%	95%	69%	90%	64%	86%
Kawasaki	45%	100%	73%	67%	76%	74%
Suzuki	54%	57%	39%	78%	58%	58%
Triumph	60%	76%	61%	100%	95%	100%
Victory	100%	n/a	85%	100%	100%	100%
Yamaha	70%	74%	76%	100%	75%	100%

* “% Cat” is the percentage of all motorcycles projected for sale that incorporated a catalyst, regardless of emission level achieved. Of the motorcycles projected for sale that have emission levels that are below the Tier II standard, “% T2 Cat” is the percentage that use a catalyst.

Appendix B. 2006 Major Manufacturer Detail

American Ironhorse Motorcycles certified one engine family. While it meets the current Tier I standard, at 1.25 g/km HC+NOx, American Ironhorse Motorcycles will likely have to shift from a carbureted system to a fuel injected system, and probably utilize at least some add-on technology such as secondary pulse-air injection to reduce its emissions by 2008.

BMW certified seven engine families for 2006. Six out of the seven were certified at emission levels less than the Tier II standard, ranging from 0.22 to 0.634 g/km HC+NOx. The seventh emits 0.98 g/km HC+NOx. The corporate fleet average is very low, at 0.43 g/km HC+NOx. BMW uses multi-port fuel injection, a three-way catalyst, and a heated oxygen sensor in all its certified families. The lowest and the highest emitting engine families both also use pulse-air injection.

Buell certified 2 engine families. Emissions for both are currently above the Tier II standard, but the engine family utilizing fuel injection and an oxygen sensor approaches this 2008 standard. The second engine family is currently certified at 1.1 g/km HC+NOx, and is a carbureted engine without any specified emission control devices. Neither engine family utilizes a catalyst. The corporate average is 0.87 g/km HC+NOx, slightly above the 2008 Tier II standard.

Ducati Motor certified 9 engine families, ranging from 0.47 to 1.33 g/km HC+NOx. Five have emissions at or below the 2008 Tier II standard, and one is slightly higher. Ducati's fleet average is 0.75 g/km HC+NOx, below the 2008 standard. Ducati uses sequential multi-port fuel injection in all its certified engine families. The lower-emitting families typically use three-way catalyst(s), and an oxygen sensor. The higher emitters utilize fuel injection but no additional technology.

Harley Davidson certified 8 engine families, with emissions ranging from 0.751 to 1.711 g/km HC+NOx. Harley Davidson appears to be having more difficulty in progressing with emission reductions, which may be attributed to their 45^o V-twin engine. Only one engine family has emissions less than the Tier II standard. Minimal emission control technology is in place, other than oxidation catalysts, which are on half their engine families. Three engine families are still carbureted, including their lowest emitter. Harley Davidson's corporate fleet average is 1.07g/km HC+NOx.

Honda certified 20 engine families for 2006, ranging from 0.3 to 1.2 g/km HC+NOx. Fifteen had emissions at or less than the Tier II standard, generally employing a catalyst as part of the emission control strategy. Engine families certifying above 0.8 g/km HC+NOx are carbureted and generally lack emission control technologies other than pulse-air injection. Honda's corporate fleet average is slightly below the Tier II standard, at 0.79 g/km HC+NOx.

Hyosung Motors certified two engine families for 2006. Both had HC+NOx emissions of 1.158, well above the level that will be required in 2008. Both are carbureted, and use pulse-air injection as the only specified emission control system. Hyosung Motors will need to make some modifications to their engines or add aftertreatment device(s) to comply with the Tier II standard in 2008.

Kawasaki certified 21 engine families in 2006, ranging from 0.4 to 1.6 g/km HC+NOx. Twelve had certified emissions at or below the Tier II standard, including 3 carbureted engine families, one with just engine modifications, and one with just pulse-air injection. Emission families that certified with emissions below 0.8 g/km HC+NOx employed a catalyst and pulse-air injection. Some also included a heated oxygen sensor, and most used sequential multiport fuel injection. The corporate fleet average was 0.84 g/km HC+NOx, approaching the 2008 Tier II standard.

Suzuki certified 20 engine families, with emissions ranging from 0.24 to 1.49 g/km HC+NOx. Seven of these engine families had emissions at or below 0.8 g/km HC+NOx. These clean engine families generally utilized fuel injection, oxidation catalyst, and/or pulse-air injection, although two of the seven low emitters are carbureted and utilize only non-specified engine modifications to achieve their low emission levels. Suzuki's corporate fleet average was 0.83 g/km HC+NOx, only slightly above the 2008 standard.

Thunder Mountain Custom Cycles certified one engine family. It is a fuel injected engine, with no additional emission control devices. It is about 25 percent above the Tier II standard, with HC+NOx emissions of 1g/km, and should be able to meet the standard with engine improvements or the use of a moderately efficient catalyst.

Triumph Motorcycles certified seven engine families, with a range of 0.224 to 1.98 g/km HC+NOx. Three out of the seven are well below the 2008 Tier II standard, and the corporate fleet average is a low 0.53 g/km HC+NOx. Triumph Motorcycles is using an assortment of standard technology including pulse-air injection, oxidation or three-way catalyst, and/or a heated oxygen sensor. Six of their seven certified engine families utilize sequential multi-port injection rather than a carburetor.

Victory Motorcycles certified two engine families, with a corporate average of 1.05 g/km HC+NOx. One engine family had certification emissions at a level below the 2008 Tier II standard, while the other engine family has much higher certification emissions, even though both engine families utilize fuel injection with a three-way catalyst, and are of a similar displacement.

Yamaha certified 15 emission families, ranging from 0.2 to 2.1 g/km HC+NOx. Nine have certified emissions at or below the Tier II standard, generally using sequential multi-port fuel injection, oxidation or three-way catalyst, and pulse-air injection. Some also use a heated oxygen sensor. Two of the nine families are carbureted. The four highest emitters (over 1.2 g/km) are all carbureted, and utilize only pulse-air injection and/or non-specified engine modifications. Yamaha's corporate average is 0.86 g/km HC+NOx, approaching the 2008 Tier II standard.

Appendix C. Certified Engine Families, 2006 Model Year

Table C- 1. Major Manufacturers

MFR	ECS DEVICE	FUEL SYS	DISP1 CC	HC+NOX	MAX HP
Am. Ironhorse		CARB	1820	1.25	134
BMW	TWC, HO2S, PAIR	MFI	1157	0.22	165
BMW	TWC, HO2S	MFI	1170	0.261	108.5
BMW	TWC, HO2S	MFI	652	0.271	50
BMW	TWC, HO2S	MFI	1130	0.431	93.8
BMW	TWC, HO2S	MFI	1170	0.47	120.6
BMW	TWC, HO2S	MFI	1171	0.634	114
BMW	TWC,HO2S, PAIR	MFI	1157	0.98	165
Buell	O2S	MFI	984	0.802	92.2
Buell		CARB	492	1.073	29.5
Ducati	2TWC, O2S	SFI	992	0.4702	100.5
Ducati	TWC, O2S	SFI	992	0.633	85.8
Ducati		SFI	748	0.697	142
Ducati	2TWC	SFI	999	0.697	142
Ducati	TWC	SFI	618	0.706	60.3
Ducati	2TWC	SFI	992	0.8168	100.5
Ducati	2TWC, O2S	SFI	992	0.9417	81.7
Ducati		SFI	992	1.3034	83.1
Ducati		SFI	996	1.3315	111.2
Harley Dav.	2OC	CARB	1449	0.751	78
Harley Dav.	OC	SFI	1549	0.918	78
Harley Dav.	2OC	SFI	1688	1.033	92
Harley Dav.	O2S	SFI	1449	1.088	70
Harley Dav.		TBI	1130	1.167	115
Harley Dav.		TBI	1247	1.257	126
Harley Dav.	OC	CARB	883	1.428	70
Harley Dav.		CARB	1199	1.711	70
Honda	PAIR, 2AFS, 2TWC	SFI	1832	0.3	117.9
Honda	PAIR, 2AFS, 2TWC	SFI	1832	0.3	117.9
Honda	PAIR,2HO2S, 2TWC	SFI	1795	0.3	104.9
Honda	PAIR, HO2S,TWC	SFI	1795	0.3	105.9
Honda	PAIR, 2HO2S, 2TWC	SFI	1832	0.3	117.9
Honda	PAIR, 2HO2S, TWC	SFI	782	0.4	106.9
Honda	TWC,HO2S, PAIR	SFI	599	0.4	105.9
Honda	PAIR, 2HO2S, 2WUOC, 2TWC	SFI	1261	0.5	124.9
Honda	PAIR, OC	SFI	998	0.6	163.9
Honda	PAIR, OC	SFI	582	0.6	50
Honda	PAIR, HO2S, TWC	SFI	599	0.7	107.9
Honda	PAIR	SFI	999	0.7	127.8
Honda	PAIR	CARB	644	0.7	39.9
Honda	PAIR, OC	SFI	919	0.8	107.9
Honda	PAIR	CARB	1099	0.8	63.9
Honda	2WUOC,OC, PAIR	CARB	600	0.9	91.9

MFR	ECS DEVICE	FUEL SYS	DISP1 CC	HC+NOX	MAX HP
Honda		CARB	745	1	45
Honda	PAIR, 2OC	CARB	1312	1	76
Honda	PAIR	CARB	583	1.1	37.9
Honda	PAIR	CARB	745	1.2	44.6
Hyosung	PAIR	CARB	647	1.158	76.4
Hyosung	PAIR	CARB	647	1.158	76.4
Kawasaki	OC, PAIR	SFI	649	0.4	71
Kawasaki	PAIR, OC	SFI	1553	0.5	65.7
Kawasaki	OC, PAIR	SFI	1553	0.5	72.4
Kawasaki	2OC, PAIR	SFI	998	0.6	173
Kawasaki	2OC, PAIR	CARB	599	0.7	108
Kawasaki	2OC, PAIR	SFI	1352	0.7	188
Kawasaki	2TWC, HO2S, PAIR	SFI	2053	0.7	85
Kawasaki	2TWC, HO2S, PAIR	SFI	2053	0.7	85
Kawasaki	2TWC, HO2S, PAIR	SFI	2053	0.7	85
Kawasaki	OC, PAIR	SFI	599	0.8	116
Kawasaki		CARB	651	0.8	48
Kawasaki	PAIR	CARB	749	0.8	68
Kawasaki	OC, PAIR	SFI	636	0.9	124
Kawasaki	2OC, PAIR	SFI	903	1	54
Kawasaki	OC, PAIR	SFI	748	1	79
Kawasaki	PAIR, OC	SFI	1470	1	66
Kawasaki	2OC, PAIR	SFI	953	1.1	125
Kawasaki	PAIR, 2OC	SFI	1553	1.1	68
Kawasaki	PAIR	CARB	498	1.1	60
Kawasaki	PAIR	CARB	805	1.5	60
Kawasaki	PAIR	CARB	997	1.6	110
Suzuki	PAIR, OC	SFI	750	0.24	146.9
Suzuki		CARB	652	0.6	33
Suzuki	PAIR, 2OC	CARB	487	0.67	47.9
Suzuki	PAIR, 2OC	SFI	996	0.72	96.6
Suzuki		CARB	644	0.73	42
Suzuki	PAIR, OC	SFI	645	0.76	65.7
Suzuki	PAIR, 2OC	SFI	996	0.8	122
Suzuki	OC, PAIR	SFI	1783	0.82	127.4
Suzuki	PAIR, OC	SFI	645	0.84	71.1
Suzuki	PAIR, OC	SFI	638	0.95	54.3
Suzuki		CARB	398	0.96	39.4
Suzuki	2OC, PAIR	SFI	1462	1.09	68
Suzuki	PAIR	SFI	999	1.18	175.5
Suzuki	PAIR, 2OC	SFI	805	1.19	52.3
Suzuki	PAIR, 2OC	SFI	805	1.19	52.3
Suzuki	PAIR, OC	CARB	750	1.23	91.3
Suzuki		CARB	1360	1.25	72
Suzuki	PAIR	TBI	385	1.34	31.5
Suzuki	PAIR	SFI	1299	1.38	172.6
Suzuki		CARB	805	1.49	54.2
Thunder Mtn		SFI	1690	1	88.6
Triumph	PAIR, 2OC	CARB	865	0.224	68
Triumph	2TWC, HO2S	SFI	2294	0.43	138

MFR	ECS DEVICE	FUEL SYS	DISP1 CC	HC+NOX	MAX HP
Triumph	TWC, HO2S, PAIR	SFI	675	0.466	121.3
Triumph	2OC,HO2S, PAIR	SFI	1050	0.876	128
Triumph	2OC, PAIR	SFI	600	0.976	106
Triumph	PAIR, HO2S, TWC	SFI	955	0.998	144
Triumph	HO2S	SFI	955	1.98	103
Victory	2TWC	SFI	1507	0.748	80
Victory	2TWC	SFI	1634	1.062	80
Yamaha	2TWC, HO2S, PAIR	SFI	998	0.2	148
Yamaha	TWC, HO2S, PAIR	SFI	599	0.4	125
Yamaha	2OC, PAIR	CARB	1063	0.4	64.1
Yamaha	TWC, HO2S, PAIR	SFI	1298	0.53	141.5
Yamaha	OC, PAIR	SFI	395	0.6	33.5
Yamaha	OC, PAIR	SFI	998	0.7	172.6
Yamaha	TWC, PAIR	SFI	600	0.7	115
Yamaha	2OC, PAIR	CARB	649	0.7	39.4
Yamaha	TWC, HO2S	SFI	1854	0.8	99
Yamaha	PAIR, OC	SFI	600	1	96.6
Yamaha	PAIR	SFI	1670	1.13	83
Yamaha	PAIR	CARB	1670	1.2	71.4
Yamaha	PAIR	CARB	599	1.34	91
Yamaha	PAIR	CARB	1294	2	96.7
Yamaha		CARB	1198	2.1	133.2

A blank in the ECS Device column means that the certification was achieved with engine modifications alone and without the use of add-on technologies.

Emission Control System Key

- HO2S Heated Oxygen Sensor
- OC Oxidation Catalyst
- PAIR Pulse Air Injection
- TWC Three-Way Catalyst
- WUOC WarmUp Oxidation Catalyst

Fuel System Key

- CARB Carburetor
- MFI Multi-Port Fuel Injection
- SFI Sequential Multi-Port Fuel Injection
- TBI Throttle Body Injection

Table C-2. Small Volume Manufacturers

MFR	ECS DEVICE	DISP1 CC	FUEL SYS	HC	HC+NOX	MAX HP
Am. Perf. Cycle		2026	CARB	0.867		108.4
Am. Perf. Cycle		1573	CARB		1.18	91.1
Aprilia	2OC	998	SFI		0.544	116
Aprilia	2OC, HO2S	998	SFI		0.649	90
Aprilia	OC	459	SFI		0.938	37
Aprilia	2OC, HO2S	998	SFI		1.135	135
Big Bear Chop.		1639	CARB	0.968		100
Big Bear Chop.		1852	CARB		1.078	102.4
Big Bear Chop.		2026	CARB		1.237	108.4
Bourget's Bike		1853	CARB		0.916	93.8
Big Dog Motorcyl		1916	CARB		1.048	120.6
Boss Hoss	TWC, O2S	5736	TBI	0.486		265
Boss Hoss	TWC, O2S	5736	TBI	0.501		265
Bimota	OC	992	SFI		0.6	83.1
Bimota	OC	996	SFI		0.8	140.4
Bimota	OC	992	SFI		1.3	84.6
BMC		1639	CARB	1.087		88.4
BMC		1852	CARB	1.095		102.4
Carefree Custom		1853	CARB	0.999		109.9
Eicher Internatnl	PAIR, TWC	499	CARB		1.108	21
Global Motorspor		1803	CARB	1.076		96.5
Hardbikes		2026	CARB		1.153	108.4
Hardbikes		2026	CARB		1.153	108.4
Hellbound Steel		2026	CARB	1.145		108.4
Hellbound Steel		1754	CARB		1.17	107.1
Illusion Cycles		1590	CARB		0.982	117.9
Illusion Cycles		1590	CARB		0.982	117.9
Irbit Motorworks	2TWC	749	CARB	0.36		36
KTM Sport Motor		625	CARB	0.636		48.2
KTM Sport Motor	2TWC	942	CARB		0.63	96.5
Moto Guzzi	HO2S, OC	1064	SFI		0.844	84.4
Moto Guzzi		1064	TBI		0.868	74
Moto Guzzi		1064	TBI		0.907	90
Moto Guzzi	OC, HO2S	744	TBI		1.102	48
MuZ		660	CARB	0.798		49.6
MuZ	2OC, O2S	999	SFI	0.857		115.2
MV Agusta Mtr		501	CARB		0.468	18.1
MV Agusta Mtr	TWC	577	CARB		0.576	45.6
MV Agusta Mtr	TWC	998	SFI		0.659	163.5
Ness Motorcycle		2032	CARB		1.022	108.4
Power Auto & Cu		1803	CARB		0.801	115.2
Patriot Motorcycl		2026	CARB	1.029		108.4
Paramount Custo		1639	CARB	1.1		102
Piaggio	OC	459	TBI		0.639	39.4
Pro-One Perfor.		2024	CARB		0.967	123.2

MFR	ECS DEVICE	DISP1 CC	FUEL SYS	HC	HC+NOX	MAX HP
Proper Chopper		1852	CARB		0.99	102.4
Rucker Perf. Mot		2032	CARB		1.215	121
Road Stertec	TWC,H02S,TC	599	MFI	0.108		80.4
Saxon Motorcycl		1819	CARB		0.955	108
Saxon Motorcycl		1573	CARB		1.06	91
S&S Cycle		1564	CARB	0.664		91
S&S Cycle		1853	CARB		1.047	102
S&S Cycle		2026	CARB		1.008	108.3
Swift Motorsports		1340	CARB		0.911	68.3
Swift Motorsports		2026	CARB		1.042	80.9
The Campagna	2OC, PAIR	1164	CARB	0.973		153
Titan Motorcycle		1853	CARB	0.708		144.7
Titan Motorcycle		2026	CARB	1.005		108.4
TP Engineering		2032	CARB		1.196	106
Ultima		2092	CARB		0.986	104
Ultra Motorcycle		1852	CARB		1.199	102.4
VCS Custom Cyc		1853	CARB	0.266		100
Vengeance Moto		1853	CARB	1.001		102
Von Dutch Kusto		1852	CARB		1.226	102.4
WestCoast Chop		1852	CARB		0.9	102.4
Westward Indust	TWC, 2HO2S	999	MFI		0.051	61.4

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