WRITTEN TESTIMONY
OF THE
MANUFACTURERS OF EMISSION CONTROLS ASSOCIATION
ON THE
U.S. ENVIRONMENTAL PROTECTION AGENCY=S

PROPOSED RULEMAKING ON CONTROL OF EMISSIONS FROM NONROAD LARGE SPARK-IGNITED ENGINES, AND RECREATIONAL ENGINES (MARINE AND LAND-BASED)

Docket No. A-2000-01
January 18, 2002

The Manufacturers of Emission Controls Association (MECA) is pleased to provide written comments on EPA's proposed regulatory program to reduce emissions from nonroad large SI engines, as well as marine and land-based recreational equipment engines. This testimony is designed to supplement MECA's oral testimony at EPA's two public hearings in October, as well as other information previously provided to EPA by MECA and individual MECA members.

MECA is a non-profit association of the world's leading manufacturers of mobile source emission control technology. MECA=s member companies have over 30 years of experience and a proven track record in developing and commercializing emission control technologies for motor vehicles. A number of our members have extensive experience in the development, manufacture, and commercial application of emission control technologies for nonroad spark-ignition (SI) engines, compression-ignition (CI) engines, and motorcycles. Our written testimony is based on research and development work being conducted by our members, their extensive experience in the field of mobile source emission control, and experience in other countries in Europe and Asia where catalyst-based emission control equipment has been installed for over 10 years on two- and four-stroke SI engines similar to those used to power the vehicles and equipment covered by EPA's proposal.

INTRODUCTION

MECA commends EPA for its initiative to address emissions from the engine applications covered by EPA's proposal. We concur with EPA's conclusion that these engine categories are important contributors to ambient air pollution. As many parties testifying at the EPA public hearings noted, exhaust emissions from these engines also adversely impact the micro-breathing environment of the equipment users. Indeed, these categories of engines operate with open cabs which results in the direct exposure of the operator to exhaust pollution. With the exception of large SI engines operated indoors that can be regulated by OSHA, no other U.S. agency is involved in insuring that the micro-environment of an operator using the equipment covered by EPA's proposal is protected.

EPA's proposal represented a good first step for review and consideration by all interested parties. However, if the rule is finalized in its current form, it will fall far short of what could be achieved and what Congress mandated in the Clean Air Act Amendments of 1990. The 1990 Clean Air Act Amendments (1990 CAAA) required EPA to study emissions from nonroad engines "to determine if such emissions cause or significantly contribute to air pollution which may reasonably be anticipated to endanger the public health or welfare . . . ." EPA subsequently made the requisite determination, noting that nonroad spark-ignition engines represent an important portion of the national hydrocarbon (HC) inventory. Having made that determination, the 1990 CAAA requires EPA to set standards that "shall achieve the greatest degree of emission reduction achievable through the application of technology which the Administrator determines will be available for the engines . . . to which the standards apply, giving appropriate consideration to the cost of applying such technology within the period of time available to the manufacturers and to noise, energy, and safety factors associated with the application of such technology."

MECA believes the major shortcoming in EPA's proposal is the control program for land-based SI recreational equipment. MECA agrees with EPA's analysis that improved fuel management systems and/or converting from two-stroke to four-stroke engines will provide useful emission reductions. We strongly believe, however, that significant additional emission reductions from these engines using catalyst-based systems are technologically feasible, cost effective, and safe. Catalyst-based systems have a proven track record in motor vehicles applications since the mid-1970s. Thus, in its current form, the proposed rule fails to take full advantage of proven technologies and control strategies that are either commercially available today or could be optimized and ready in the near future. These technologies could provide significant additional reductions of harmful pollutants from these engines. Quite simply, if EPA's rule is finalized as proposed, an important opportunity to reduce emissions and better protect the public health will be lost. We believe, however, the opportunity exists for EPA to build on its proposal by correcting the deficiencies when it finalizes the rule later this year and thereby properly insure compliance with the Clean Air Act.

NONROAD SI ENGINES >19kW

MECA concurs with EPA, as stated in the Draft Regulatory Support Document, that engine and equipment manufacturers can take advantage of three-way catalytic converter technology to not only substantially reduce NOx, CO, and HC emissions from this category of engines, but also to improve engine performance and fuel consumption. Catalyst technology has been commercially applied to large nonroad SI engines for over 35 years. Indeed, over 150,000 catalyst-equipped engines have been sold. Closed-looped, three-way catalyst systems have been employed successfully in automotive applications since 1983 and in large nonroad SI engines for six years.

We also agree with EPA that, as discussed in the Draft Regulatory Support Document, variations between engines in this category do not significantly affect their potential to reduce emissions or the cost to meet the proposed emission standards. Although large nonroad SI engines are used in a wide range of applications, emission control technologies have already been used in many applications for occupational health concerns and have proven to be durable. We, therefore, do not believe application specific standards are necessary.

MECA supports EPA's proposal to harmonize with California's standards beginning in 2004 (Phase 1). We believe, however, the standards proposed for 2007 (Phase 2) could be more stringent. We recommend that EPA establish Phase 2 standards in the range of 1.4 to 2.8 g/kW-hr for HC + NOx and a 3.4 g/kW-hr CO for both gasoline- and propane fueled engines. These levels of emission control have been demonstrated with optimized three-way catalyst technology and electronic fuel injection systems. Indeed, levels lower than this have been certified in California. For example, ARB in 2001 certified a 7.5L LPG SI engine that tested at an HC+NOx level of 0.64 g/bhp-hr. With electronic controls and closed-loop catalyst systems, our experience is that there is no "trade-off" for the simultaneous control of CO and HC + NOx emissions. We also believe that these standards can be achieved considerably in advance of 2007.

MECA supports the use of the transient test-cycle proposed by EPA. Certification testing should reflect, as closely as possible, the real world operating emission performance of the regulated engines. EPA's proposed test cycle achieves this result.

MECA also supports the concept of establishing field testing limits. We believe the levels proposed by EPA assume a deterioration factor in emission control performance higher than what we expect will occur in real use. With electronically controlled closed-loop three-way systems used on this category of engines, there will be little deterioration in performance, particularly given the fact that, by the time the standards take effect, only low-sulfur gasoline fuel will be available and propane fuel is sulfur free. The varying composition of propane fuel can affect emission control performance, but with the oxygen controlled fuel metering system, the impact of varying fuel composition is sufficiently mitigated. However, propane fuel contaminants like heavy-end hydrocarbons and sulfur can adversely affect emission control performance. Therefore, to maximize the effectiveness of advanced emission controls on these engines, we support establishing uniform fuel quality specifications for propane fuel. We recommend that EPA consider harmonizing fuel quality specifications with California's requirements.

Based on general comments from our members, EPA cost estimates for the advanced emission control systems that will be used on these categories of engines appear to be too high. Several MECA members have indicated they plan, on an individual basis, to provide more specific information on the costs of various components of the emission control system. We also anticipate, based on experience with emission control technology costs in other applications, that as the sales volume of control systems increase, costs will almost certainly be reduced. In any event, as demonstrated in the Draft Regulatory Support Document, the lifetime savings in improved fuel consumption, lower maintenance and reliable performance more than offsets the cost of applying the advanced technology that will be used to meet EPA's proposed standards. This will also be true with the standards recommended by MECA.

RECREATIONAL VEHICLES -- OVERVIEW

EPA has based its emission control programs for ATVs and off-road motorcycles principally on the utilization of four-stroke engines and improved fuel management systems. For snowmobiles, the proposed standards are based on modified two-stroke engines with improved fuel delivery systems and some market penetration of four-stroke engines. Other than the Phase 2 standards for ATVs where EPA has identified catalyst-based systems as one of several available compliance options, EPA's proposed standards for land-based recreational SI engines places no reliance on catalyst technology despite the proven track record of catalyst systems on similar engine applications and catalyst technology's proven record of emission control efficiency, cost effectiveness, durability and reliability. The Phase 2 ATV standards do not become fully effective until 2010. Thus, under EPA's current proposal, catalyst-based technology will not be employed on even this application to meet mandatory standards until eight years from now and twenty years after the Clean Air Act mandated that off-road engines contributing to harmful air pollution be controlled using the best technology that could be available.

MECA believes that catalyst technology can effectively be used with both two-stroke engines with improved fuel management systems and four-stroke recreational vehicle engines to significantly further and cost-effectively reduce emissions from these engines. As discussed below, catalyst technology combined with improvements in engine and fuel delivery system design has been applied to non-automotive spark-ignited two- and four-stroke engines for a number of years and has been shown to provide significant emission reductions of HC+NOx, CO and, in the case of two-stroke engines, PM emissions. Industry objections to applying catalyst technology to two- and four-stroke recreational engines have included durability, packaging constraints, safety, performance, and cost of the systems. Actual commercial experience with both two-stroke and four-stroke two-wheel vehicles has demonstrated that all of these concerns are easily addressed.

Small SI Engine Regulatory Programs Based on Catalyst Technology -- Catalyst technology has been utilized successfully on motorcycles and mopeds for 10 years. During that time, over 15 million two- and three-wheel vehicles have been equipped with catalyst systems. Taiwan was the first country to establish catalyst-based standards in 1992 and it subsequently tightened its standards twice more in the 1990s. Based on the resounding success of Taiwan's pioneering program and the effective performance of catalyst technology, other countries around the world have adopted or are planning to adopt control programs based on the use of catalyst technology, including Thailand, India, Malaysia, China, Japan, and countries in the European Union. Appendix 1, attached to this testimony, summarizes current and proposed motorcycle emission regulations worldwide.

Catalyst Emission Control Capabilities -- Catalyst technology applied to two-stroke motorcycles and mopeds has demonstrated a capability of reducing emissions in the range of 50-60 percent for HC, and 50-80 percent for CO as reported in SAE Paper No. 2001-01-3814.

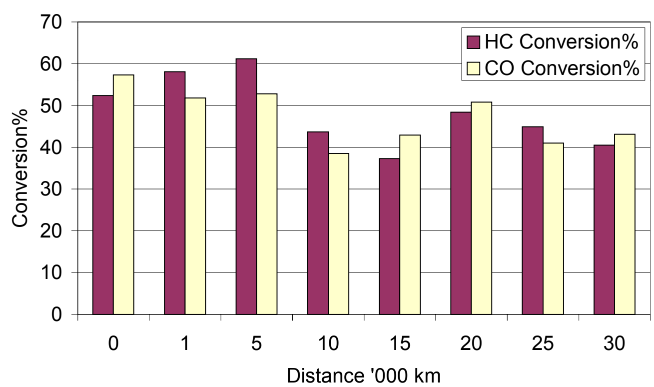
If secondary air injection is used, control efficiencies in excess of 90% for both HC and CO can be achieved.

HC speciation work performed on tailpipe emissions from a two-stroke motorcycle equipped with a catalyst designed to achieve a 30% reduction in total HC found significantly higher reductions associated with the more reactive HC species including benzene, 1,3-butadiene, polyaromatic hydrocarbons, and others. Some of these toxic compounds were reduced in excess of 80% (See SAE Paper No. 2000-01-1846).

Data for PM reductions from two-stroke engines is limited and measuring PM emissions in this application is difficult. We estimate, however, that since most of the PM emitted from gasoline two-stroke engines is HC-based and that with a catalyst-equipped two-stroke engine the typical white smoke emissions are no longer visible, PM reductions would be in the range of 50 percent.

Catalyst Durability – MECA member companies are designing and manufacturing catalyst technologies to successfully meet demanding durability requirements throughout the world. For example, since 1998 Taiwan has imposed a 15,000 km durability requirement. India has proposed a 30,000 km durability requirements for all two- and three-wheeled vehicles for 2003 and a 50,000 km requirement beginning in 2005. Europe has proposed a 30,000 km durability requirement for 2003 and a 50,000 km durability requirement for 2006 for all non-moped motorcycles. Catalyst technology has demonstrated outstanding durability on two-stroke engines, as shown in Figure 1, and on four-stroke SI engines as well. Indeed, catalyst manufacturers supplying the motorcycle market in Asia note that it is not uncommon for the two-stroke engine to fail before the catalyst.

Figure 1
Two-Stroke Catalyst Durability Over the Indian Drive Cycle
(ref. SAE Paper 2001-01-0003)



Four-stroke engine durability for motorcycles under similar aging and test evaluation conditions is expected to be as good or even better than that demonstrated in Figure 1 for two-stroke engines for the reason that lower engine-out emissions are associated with four-stroke engines and also because four-stroke engines have more advanced engine designs and fuel metering control.

To meet rigorous durability requirements experienced in actual use, catalyst technology is subjected to demanding catalyst aging and physical integrity evaluations. These tests include on-road durability demonstrations, bench testing where the catalyst-equipped engines are operated at wide open throttle for 100 hours, and/or hot vibration physical integrity tests in which the catalyst housing is subjected to cold water quenching and over 100 G force of vibration over extended periods of time (typically in the range of 100 hours). These durability tests are many times more severe than the operating conditions that an ATV or off-road motorcycle would typically experience even under the most extreme actual operating conditions.

Control System Packaging/Impact on Performance – The regulated industry maintains that catalyst systems cannot be utilized on land-based recreational equipment because of packaging constraints associated with the limited space available on the vehicle to install the device, the greater space velocity through the catalyst compared to an automobile traveling at the same speed, and the potential backpressure build-up that could adversely affect performance. Packaging is an engineering challenge, but experience in related applications has clearly demonstrated that these challenges can be met. This is demonstrated by the fact that catalyst technology has been successfully designed, packaged, and equipped on over 15 million motorcycles worldwide and over 500,000 two-stroke and approximately 400,000 four-stroke engines used on lawn and garden equipment which presented similar packaging challenges.

Catalyst formulations and substrate designs have been developed, and continue to advance, which maximize emission control performance for small SI engines while minimizing the impact on backpressure and vehicle performance (See e.g., SAE Paper Nos. 2001-01-1821 and 2001-01-3814). A wide variety of concepts have been commercially applied to address the issue of limited space available on smaller vehicles. For example, in the case of on-road motorcycles and mopeds, packaging techniques have included placing the catalyst within the muffler system, mounting the catalyst close to the manifold, and using catalyst coated plates and tubes, including flexible tube designs for exhaust pipes. These types of packaging strategies do not add any volume or complexity to the vehicle.

Operator Safety – Contrary to the claims of the regulated industry, catalyst-based systems can be easily and safely applied to land-based recreational equipment. Indeed, the 10 year experience with on-road motorcycles and mopeds is proof of this fact. The countries that have successfully implemented catalyst-based regulatory programs have not identified any special safety issues associated with the use of catalyst technology on motorcycles and mopeds in real world applications. This fact is particularly significant given that it is not uncommon in India or Southeast Asia for catalyst equipped motorcycles to carry two to four riders in all manner of attire.

Costs – Catalyst technology can be cost effectively applied to land-based recreational equipment. Certainly, the cost of catalyst technology presented no roadblock to adopting or implementing catalyst-based motorcycle and moped standards in countries such as Taiwan, Thailand, China, and India where per capita income is much less than in the United States. Experience in countries with motorcycle emission control programs has shown that the costs of catalyst based systems range from as low as $5 to up to about $100, depending on a variety of factors including the engine size, level of engine out emissions, level of the standards, packaging considerations, and the sales volume of catalyst system.

Two-Stroke SI Handheld Engines is an Illustration of What Can Be Done -- When EPA first announced its intention to regulate emissions from two-stroke SI engines used in handheld lawn and garden equipment, the regulated industry raised precisely the same arguments that are presently being raised by recreational equipment manufacturers as to why catalysts cannot not be used to control emissions. MECA and its members acknowledged that applying catalyst technology to these small two-stroke engines posed significant challenges, but we expressed our view that it could be done. California's Air Resources Board and later the U.S. EPA refused to accept industry's arguments and the regulatory agencies established stringent standards based on the capabilities of catalyst technology. Now, nearly three years after the ARB established its standards, over 500,000 catalyst-equipped two-stroke engines have been sold for use on a variety of lawn and garden equipment, including chainsaws, trimmers, and leaf blowers.

The line of products being offered by Husqvarna offers a compelling illustration of what is achievable by developing and integrating a complete engine/catalyst/exhaust system. Husqvarna's catalyst-equipped lawn and garden products not only achieve greater than a 60 percent reduction in NOx+HC and CO, but they eliminate visible smoke and odor, have a 30 percent improvement in fuel economy and 40 percent improvement in power. These products meet the U.S. Forestry Surface Temperature requirements and noise has been reduced by two decibels.

This remarkable success story concerning the application of catalyst technology to two-stroke SI handheld engines would not have occurred had ARB and EPA accepted industry's arguments and failed to adopt rigorous standards. The issue now before EPA is whether it will simply accept the recreational equipment industry's argument and implement a weak program or, as in the case of the SI handheld engine rule, establish regulations that stimulate technology development that can result in superior products with substantially lower emissions as has been already demonstrated in developing countries.

ALL-TERRAIN VEHICLES (ATVs)

We fully concur with the EPA's technical analysis that a variety of emission control strategies are available for use on ATVs, including base engine improvements, improved fuel-system calibrations, electronic fuel injection, air injection, and catalyst technology. We believe, however, that EPA should not delay for eight years standards that would take full take advantage of the emission reduction capabilities of catalyst-based systems. The four-stroke engines utilized on ATVs are not unlike the automotive engines of the early 1980s. These engines, with the proper improvements in fuel delivery systems, can readily employ closed loop three-way catalyst systems that can achieve emission reduction levels equivalent to the 1983 model year light-duty vehicle standards.

Therefore, we recommend that EPA base its 2006 standards on levels similar to the 1983 on-road light-duty vehicle (LDV) standards. The levels for ATVs equivalent to the 1983 LDV standards would be less than 1g/km HC+NOx and around 7g/km for CO if EPA finalizes a test procedure that includes cold-start emissions and around 2g/km if it does not. As an alternative, EPA could pull forward the 2009 1.0 g/km HC+NOx standard in 2006 and then implement the more stringent standards in 2009. If EPA follows this alternative, we recommend that the CO standard be tightened, as discussed above, because with a three-catalyst system, CO emissions will be well below EPA's proposed 25g/km level.

OFF-HIGHWAY MOTORCYCLES

MECA believes EPA's decision not to propose standards for off-highway motorcycles that take into consideration the additional emission controls benefits that could be achieved using catalyst-based standards misses an important opportunity to achieve significant and cost effective emission reductions from these vehicles. EPA mentions the issues of packaging, safety and power loss, but did not provide an analysis of catalyst technology application to off-road motorcycle engines. The breadth of successful experience with catalyst technology on both on-road two- and four-stroke motorcycles, as discussed above, makes a compelling case for establishing more stringent standards for off-road motorcycles . The fact that these motorcycles operate off-road alone does not justify ignoring catalyst technology. The concerns about applying catalyst technologies being raised by industry, such as durability, packaging, costs and power loss, were discussed above. Catalyst technology has proven to be effective, durable, safe, and cost effective and the case would be no less true for off-highway motorcycle applications than they have been for on-highway applications.

We recommend that EPA base its 2006 Phase 1 standards and 2009 Phase 2 standards on the final European 2003 and 2006 standards, respectively, that are expected to be finalized prior to the time EPA is under a court order to finalize its rule.

SNOWMOBILES

EPA based it its proposed 2006 standards for snowmobiles on applying engine modifications to two-stroke engines, clean carburetion, and/or direct or semi-direct fuel injection. To meet the 2010 standards, EPA anticipates manufacturers will employ direct injection systems or convert to 4-stroke engines. EPA does not analyze in its proposal the possible application of catalyst technology to two- and four-stroke snowmobile engines.

Of the various nonroad SI engines covered by EPA's proposal, application of catalyst technology to snowmobiles powered by two-stroke engines is by far the most challenging. While catalyst technology and systems strategies applied to two- and four stroke motorcycles provide useful experience, applying catalyst technology to two-stroke snowmobile engines does involve additional engineering considerations. Most notable are high space velocities with high power demands that give rise to special thermal management considerations due to the high chemical energy content of the exhaust gases and backpressure considerations. We believe these engineering challenges can be addressed by employing the experience gained over the past 30 years in automotive catalyst technology and novel catalyst coating techniques like applying catalyst coatings to the interior surfaces of the exhaust system.

Notwithstanding the challenges mentioned above, MECA believes low efficiency catalyst technology with a 30 percent total HC reduction capability could be applied to two-stroke snowmobile engines with improved fuel delivery systems, cooling air rooted to the exhaust and a properly designed catalyst/muffler system. As noted above, such a catalyst would achieve significantly greater reductions of the more reactive HC species such as benzene, and would also reduce PM, all but eliminate the white smoke, and reduce MTBE from the exhaust. For four-stroke snowmobiles equipped with fuel injection systems and properly optimized engine/catalyst/exhaust systems, levels of 60 to 80 percent reductions of HC could be achieved.

Therefore, we recommend that EPA evaluate the feasibility of applying catalyst technology to snowmobile engines. We would welcome the opportunity to work with EPA and the snowmobile industry on this issue.

RECREATIONAL MARINE DIESEL ENGINES

We concur that the standards proposed by EPA for >37 kW marine diesel engines are technologically feasible and can be met in a cost-effective manner. We also agree with EPA that marine diesel engines can take advantage of the technological advances made to reduce emissions from highway and nonroad diesel engines and that crankcase emissions from marine diesel engines also can be controlled. We believe, however, that other technologies exist that could be integrated with these advances to further reduce emissions from marine diesel engines including diesel oxidation catalysts, diesel particulate filters, and catalytic NOx controls. We recommend that EPA consider harmonizing the marine diesel engine standards with EPA's current and future land-based diesel engine standards.

VOLUNTARY LOW-EMISSION STANDARDS

MECA supports the creation of "Blue Sky" or voluntary low-emission standards for all categories of engines covered by the NPRM. The standards should be based on early compliance with the mandatory requirements and for engines certified at levels below the mandatory requirements.

EMISSION PERFORMANCE LABELING

MECA strongly supports the concept of consumer labeling so that the consumer can make informed decisions regarding the emission levels of their purchase. California's program for spark-ignited marine engines could serve as a model for EPA. We encourage the Agency to implement a consumer labeling program.

CONCLUSION

In closing, MECA agrees with EPA that employing advanced engine designs such as improved fuel metering systems and/or converting from two-stroke to four-stroke engines will provide important emission reductions. We believe, however, that EPA should strengthen its proposal by adopting final standards that are based on the combination of engine design improvements and catalyst-based emission control systems. As stated above, catalyst systems are technologically feasible, cost effective and safe for the engine applications covered by EPA's rulemaking. Catalyst technology, applied to highway vehicles since 1975, large off-road SI engines for 35 years, and nearly one million small SI engines on a growing variety of lawn and garden equipment, has a proven track record and this experience will greatly facilitate applying catalyst technology to the SI engines covered by EPA's proposal.

By strengthening its proposed program and basing the final standards on emission levels achievable with advanced engine designs *and* catalyst technology, EPA will carryout the mandate of the Clean Air Act and will insure that emission reductions needed to help protect the public health are achieved. If EPA finalizes the standards as proposed, we believe an important opportunity to achieve significant emission reductions will be lost for many years to come. We would welcome the opportunity to work with EPA, the regulated industry and other interested parties as the Agency moves forward with finalizing this rule.

Appendix 1

Summary of Current and Future Worldwide Motorcycle Emission Regulations

Country	Vehicle	Homologation/Production (COP) Mass Emissions(g/km)					Idle Test		Durability	Remarks
		HC	CO	NOX	HC+NOx	Test Cycle	HC	CO	Test	
European Union (EU)	Moped		6		3	ECE R47				Current (Stage 1)
	2-stroke	4	8	0.1		ECE R40		4.50%		Current (Stage1)
	4-stroke	3	13	0.3		ECE R40		4.50%		Current (Stage 1)
	Moped		1		1.2	ECE R47		4.50%		6/1/2002 Stage 2
	2,4-S =<150cc	1.2	5.5	0.3		ECE R40		4.50%	30K km	2003 Stage 2 (Durability Proposed)
	2,4-S >150cc	1	5.5	0.3		ECE R40		4.50%	30K km	2003 Stage 2 (Durability Proposed)
	2,4-S =<150cc	0.8	2	0.15		Cold Start 6-cycle ECE R40			50K km	Stage 2 Tax Incentive/Proposed 2006 Stage 3 (Set
	2,4-S >150cc	0.3	2	0.15		Cold Start ECE R40+EUDC			50K km	Stage 2 Tax Incentive/Proposed 2006 Stage 3 (Set
Switzerland	Moped	0.5	0.5	0.1		ECE R47	0.1 g/min	0.1 g/min		Current
	2-stroke	3	8	0.1		ECE R40		2.50%		Current
	4-stroke	3	13	0.3		ECE R40		2.50%		Current
India	All MCs		2/2.4		2/2.4	India Drive		4.50%		Current
	All MCs		1.3		1.3	India Drive			30K km	2003 Proposal
	All MCs		1		1	India Drive			50K km	2005 Proposal
China: National	Moped		6		3	ECE R47				Stage 1: New models from 1/1/2002; all from 1/1/20
	2-stroke	4	8	0.1		ECE R40		4.50%		New models from 1/1/2002; all from 1/1/2003
	4-stroke	3	13	0.3		ECE R40		4.50%		New models from 1/1/2002; all from 1/1/2003
	Moped		1		1.2	ECE R47				Stage 2: New models from 7/1/2005; all from 7/1/20
China: Beijing	2-stroke						8000	4.50%		Produced before 1/1/2001
	4-stroke						2200	4.50%		Produced before 1/1/2001
	2-stroke		4.5		3	ECE R40	3000	1.50%	6K km	Stage 1: Produced after 1/1/2001
	4-stroke		4.5		3	ECE R40	300	1.50%	6K km	Stage 1: Produced after 1/1/2001
	2-stroke		3.5		2	ECE R40	3000	1.50%	15K km	Stage 2: Produced after 1/1/2004
	4-stroke		3.5		2	ECE R40	300	1.50%	15K km	Stage 2: Produced after 1/1/2004
Japan	2-stroke	5.26	14.4	0.14		ISO 6460	7800 ppm	4.50%		Current
	4-stroke	2.93	20	0.51		ISO 6460	2000 ppm	4.50%		Current

Korea	<50cc	4	8	0.1		ECE R47			6K	Current
	>50cc 2-S	4	8	0.1		ECE R40			6K	Current
	>50cc 4-S	3	13	0.3		ECE R40			6K	Current
Singapore	All MCs		12		5	FTP				Current
Taiwan	All MCs		3.25/3.5		1.75/2.0	CNS 11386	6000 ppm	4.00%	15K km	Current (Stage 3)
	2-stroke		7		1	CNS cold start	3000 ppm	1.50%	15K km	2003: Cold start test with sampling
	4-stroke		7		2	CNS cold start		1.50%	15K km	40s after engine start (Stage 4)
Thailand	All MCs	3	4.5			ECE R40	10000 ppm	4.50%	12K km	Current
Canada	All MCs		12		5	FTP				Current (<50cc excluded)
USA: 49 states	All MCs		12		5	FTP				Current (<50cc excluded)
USA: California	50-279cc	1	12			FTP				Current (<50cc excluded)
	280-699cc	1	12			FTP				Current (HC as Corporate Avg.)
	>700cc	1.4	12			FTP				Current (HC as Corporate Avg.)
	<280cc		12		1.4	FTP				2004 Proposed (HC+NOx as Corp. Avg.)
	>280cc		12		0.8	FTP				2008 Proposed (HC+NOx as Corp. Avg.)