Summary of the Future Emission Reduction Measures for Motorcycles from The Future Policy for Motor Vehicle Emission Reduction (The 11th Report) and Current Discussion in Japan

Ministry of the Environment, JAPAN

The Future Emission Reduction Measures for Motorcycles

(1) Viewpoints on Reviewing Motorcycle Emission Reduction Measures

☐ Background

- Although the emission regulation of the 2006 Standard is applied, the amount of HC and CO emissions per distance travelled is still much higher than those of four-wheeled vehicles.
- Although the tailpipe emission standard has been implemented for the first time in 1998 and then reinforced in 2006, the relative contribution of evaporative gas within the emission has been higher.
- It is important to control the amount of emission through monitoring the in-use malfunction of emission reduction systems.

Total Emission Amounts of Motorcycles and Passenger Vehicles (PVs)

FY	Vehicle Types	Driving Distance (Million km/year)	Emission Amount (t/year)				Average Emission Amount (g/km)			
			NOx	HC	CO	CO_2	NOx	HC	CO	CO_2
FY2010	Motorcycle	15,189	1,790	8,155	62,039	806,796	0.118	0.537	4.084	53.117
	Kei-PV	116,086	4,027	3,055	74,610	18,084,031	0.035	0.026	0.643	155.781
	PV	391,102	12,644	6,280	196,021	67,447,833	0.032	0.016	0.501	172.456
	PV total	507,188	16,671	9,335	270,631	85,531,863	0.033	0.018	0.534	168.639
FY2020 (Est.)	Motorcycle	15,189	1,047	1,394	21,506	844,040	0.069	0.092	1.416	55.569
	Kei-PV	114,908	835	1,821	51,025	13,771,441	0.007	0.016	0.444	119.847
	PV	392,463	2,834	2,986	105,909	63,480,689	0.007	0.008	0.270	161.750
	PV total	507,371	3,669	4,807	156,934	77,252,131	0.007	0.009	0.309	152.260

Note) For Kei-PV and PV, gasoline vehicle only

Motorcycle Emission Regulation of UN, EU and Asia

- In EU, Worldwide-Harmonized Motorcycle Test Cycle (WMTC) was introduced in 2007. The regulation will be reinforced in 2016 as in new EURO 4.
- Many Asian countries where the motorcycle markets are expanding now have implemented the regulations modeled after EU, although may not be the latest. It is expected that these countries will introduce EU standards with WMTC in the near future.

Prospect of Motorcycle Emission Regulation of Each Country or Area

region	country	test cycle	2012	2013	2014	2015	2016	2017	2018	2019	2020
ASIA	JAPAN	motorcycle mode	2nd(～oct)								
		WMTC	2nd(oct～)					3rd			
	TAIWAN	ECE40+EUDC	EURO－3								
		WMTC							EURO-4 STUDY		
	CHINA	ECE40+EUDC	kuni－3								
		WMTC						kuni-4(EURO-4 STUDY)			
	KOREA	ECE40+EUDC	EURO－3								
	PHILIPPINE	ECE40	EURO－2(Sep～)			EURO－3(Sep～)					
	VIETNAM	ECE40	EURO－2					EURO－3			
		WMTC				sutdy					
	THAILAND	ECE40+EUDC	EURO－3								
		WMTC							EURO-4 STUDY		
	MALAYSIA	ECE40	EURO－2		EURO－3						
	SINGAPORE	ECE40	EURO－1		EURO-3 STUDY						
	INDONESIA	ECE40	EURO－2	EURO－3(Aug～)							
		WMTC		EURO－3(Aug～)(select)							
	INDIA	ARAI	BS－3								
		WMTC				BS－4 STUDY(ex-EURO－4 level)					
	PAKISTAN	ECE40	EURO－2								
	IRAN	ECE40	EURO－2								
	TURKEY	ECE40+EUDC	EURO－3								
EU	EU	ECE40+EUDC	EURO－3								
		WMTC	EURO－3(select)				EURO-4				EURO-5
US	US	LA-4	Tier2								
SOUTH AMERICA	BRASIL	ECE40+EUDC	EURO－3								
		WMTC			PROMOT4(1st.)EURO-3.5		PROMOT4(2nd.) limit value:ex-EURO-4 level				
	COLONBIA	LA-4	Tier1								
		ECE40	EURO-2			EURO-3 STUDY					
	CHILE	LA-4	Tier2								
		ECE40+EUDC	EURO－3								
		WMTC	EURO－3								

JAPAN	2nd		3rd	
CHINA	kuni－3		kuni－4	
INDIA	BS－3	BS-4		
EU	EURO－3	(ex-EURO-4)	EURO－4	EURO－5
US	Tier2			
BRASIL		PROMOT4(2nd)		

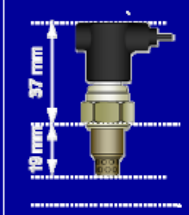
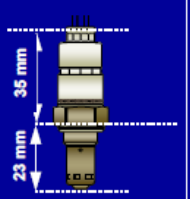
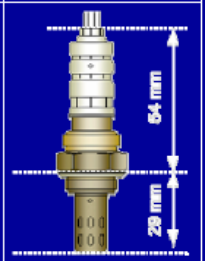
In addition to reinforcing the motorcycle regulation to ensure the emission reduction according to the actual air condition and the motorcycle riding pattern in Japan, it is also important to consider harmonization with international standards that may contribute to reducing the development costs and time.

(2) Tailpipe Emission Reduction Measures

☐ Current Technology and Challenges

- Current measures for tailpipe emission reduction is based on the feedback control for theoretical air-fuel ratio, using “Electronically Controlled Gasoline Injection + Three-way Catalyst + O2 Sensor”.
- Compared to four-wheeled vehicles, motorcycle emission reduction technology is constrained not only by the smaller body size, but also by consideration of contact with roads surface when inclined, as well as damages on parts and human body from release of exhaust heat and vibration.
- Each part of emission reduction devices is subject to pursuit of downsizing and lightening, as well as systemic simplification and part communization for cost reduction.

O2 Sensors for Motorcycles (with and without heater) and for PVs

	二輪車用 ヒータレスO2センサ	二輪車用 積層ヒータ付O2センサ	四輪車用O2センサ
外観及び寸法			
体積(四輪車用比)	▲34%	▲46%	–
質量(四輪車用比)	▲45%	▲49%	–
センシング部投影面(四輪車用比)	▲78%	▲33%	–

Resource：JAMA

☐ The Forthcoming Permissible Limits of Motorcycle Tailpipe Emission

- Considering the new EURO 4 becoming effective from 2016 and allowing adequate time for due technological development by motorcycle manufacturers, it is considered appropriate that application of new regulation in Japan occurs by the end of 2016.
- Emission reduction technologies expected to be developed by 2016:
  - ➢Optimization of fuel injection control
  - ➢Introduction of variable valve actuation mechanism
  - ➢Increase in catalyst volume
  - ➢Quick activation of catalyst by ascending exhaust gas temperature quickly
  - ➢High efficiency of catalyst

[Recommendation]

The new permissible emission limits are set based on WMTC classes and will begin by the end of 2016.

Unit [g/km]

Category	Class 1			Class 2			Class 3		
Pollutants	THC	CO	NOx	THC	CO	NOx	THC	CO	NOx
Next Limit	0.30	1.14	0.07	0.20	1.14	0.07	0.17	1.14	0.09
Current Equivalent Limit	0.45	2.2	0.16	0.27	2.62	0.21	0.27	2.62	0.21
Reduction Rate	33.3%	48.2%	56.3%	25.9%	56.5%	66.7%	37.0%	56.5%	57.1%
(Ref) EURO 4	0.38	1.14	0.07	0.38	1.14	0.07	0.17	1.14	0.09

☐ Estimated Amount of Reduction in Tailpipe Emission in 2020

The new regulation is expected to bring additional effect of 20% reduction of HC in 2020. In the future, further reduction is expected, owing to further diffusion of new types of motorcycles.

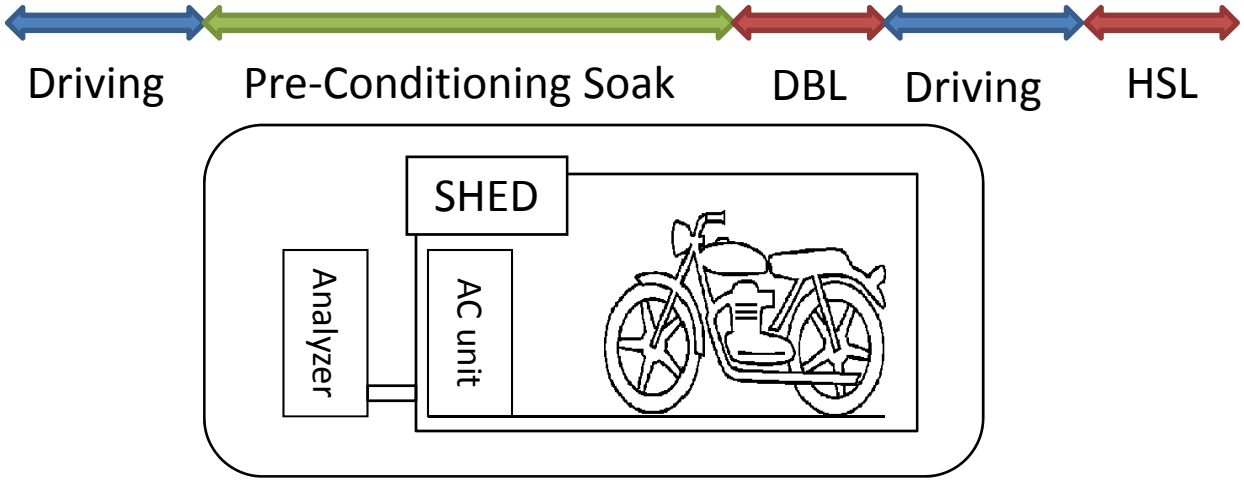
Unit [t/year]

Pollutants	Tailpipe Emission	Class 1	Class 2	Class 3	Total
THC	Without New Regulation	947	245	202	1,394
	With New Regulation	724 ▲23.5%	216 ▲11.8%	170 ▲15.8%	1,110 ▲20.4%
CO	Without New Regulation	11,561	6,839	3,107	21,506
	With New Regulation	7,245 ▲37.3%	5,083 ▲25.7%	2,362 ▲24.0%	14,690 ▲31.7%
NOx	Without New Regulation	606	201	240	1,047
	With New Regulation	355 ▲41.4%	142 ▲29.3%	171 ▲28.8%	669 ▲36.1%

(3) Measures for Reduction of Fuel Evaporative Emission

☐ Test Method

- California State (CA) Evaporative Emission Test for Motorcycles is used by several other and will be adopted to EU regulation from EURO 4.
- CA Evaporative Emission Test should be introduced for the following reasons:
  - ➢ The test is regarded as an alternative of Passenger Vehicles (PVs) evaporative emission test, which consists of 24 hour Diurnal Breathing Loss (DBL) and Hot Soak Loss (HSL) tests.
  - ➢ One-heating DBL test is adequate because 60 to 80% motorcycles are parked only once during the daytime in Japan.



CA Evaporative Emission Test Process

☐ Discussion Concerning the Introduction of CA Evaporative Emission Test

1. Duration of Test Time: 1 hour for CA DBL, 24 hours for DBL on PVs

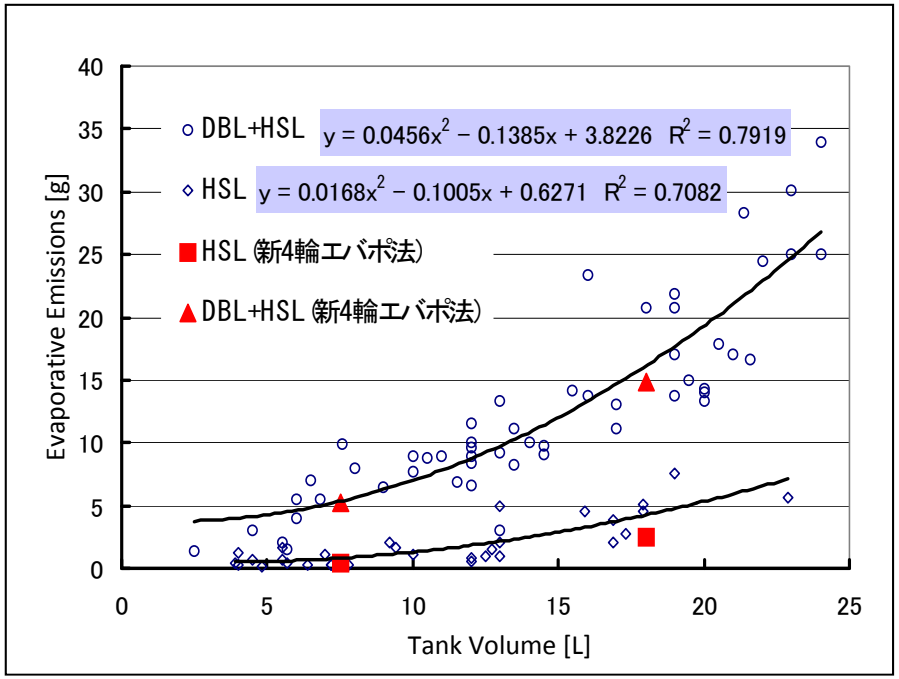
- The following formula is for calculation of evaporative emission and does not include the duration of test time.

  (THC emission factor per tank air space volume in the tank [g/gal])
  ＝0.00817 × EXP（0.2357 × Rvp）× {EXP（0.0409 × T2）－EXP（0.0409 × T1）}

  Rvp: Reid Vapor Pressure of Gasoline (PSI)
  T1: Fuel Temperature at Start (F)
  T2: Fuel Temperature at Finish (F)

- The motorcycle test results by CA Evaporative Emission Test (EET) method is in correlation with those of the PVs test method.

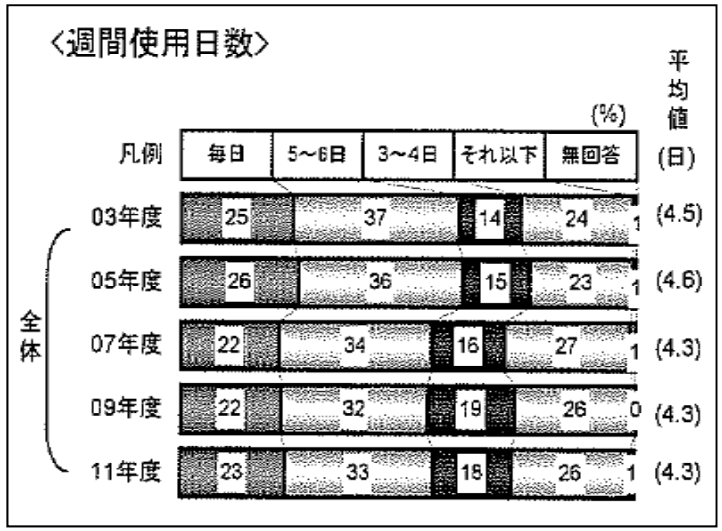
[Conclusion]
CA EET is thus regarded as an alternative of PVs EET, constituting 24　hour DBL and HSL tests.

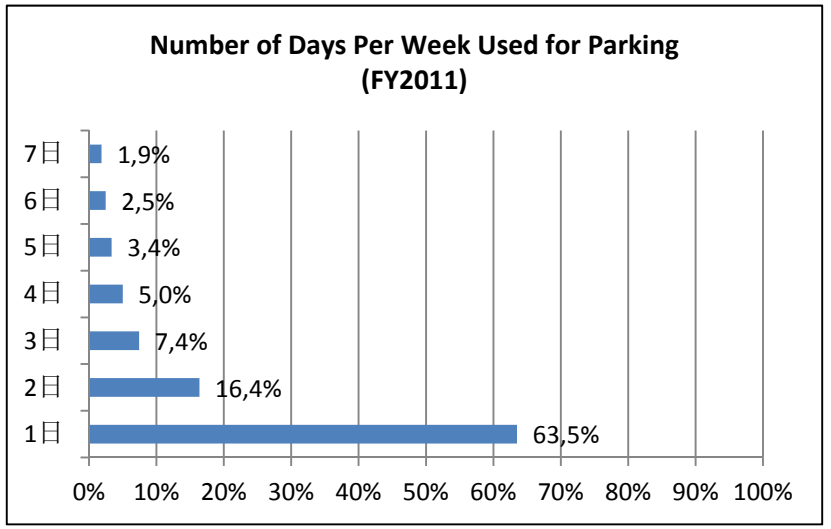


Motorcycle Evaporative Emissions

2. Is the CA DBL Test Enough?

- According to Motorcycle Market Survey by Japan Automobile Manufacturers Association, Inc. (JAMA), 56% answered as using motorcycles 5 days or more per week, 4.3 days per week on average.
- Based on the distribution of the number of days of use per week, we estimated how many days motorcycles are parked continuously : 63.5% for 1 day and 16.4% for 2 days. Considering the fact that most people use for commuting, most of those parked for 2 days are regarded as parked only once during a daytime (e.g. parking from Saturday evening through Monday morning).





[Conclusion]

One-heating DBL Test is adequate, as 60 to 80% motorcycles are parked only during the daytime.

☐ Permissible Evaporative Emission Limit for Motorcycles

- In Japan, permissible evaporative emission limit from PVs is 2.0 g/test. Both the U.S. limit from motorcycles and EURO 4 limit are 2.0 g/test.
- Setting 2.0 g/test as the permissible evaporative emission limit will reduce 30% motorcycle evaporative emission in FY2020.

➢ Estimated Amount of Evaporative Emission from Motorcycles in FY2020 (t/year)

Evaporative Emission	Class 1	Class 2	Class 3	**Total**
Without Regulation	953	1,476	1,847	4,275
With Regulation	953	946	1,086	2,985
Reduction Rate	0.0%	35.9%	41.2%	**30.2%**

➢ Estimated Tailpipe and Evaporative Emissions from Motorcycles in FY2020 (t/year)

Tailpipe and Evaporative Emissions	Class 1	Class 2	Class 3	**Total**
Without New Regulation	1,900	1,721	2,049	5,670
With New Regulation	1,677	1,162	1,256	4,095
Reduction Rate	11.7%	32.5%	38.7%	**27.7%**

[Recommendation]
The motorcycle evaporative emission regulation is modeled after the CA Evaporative Emission Test, with the permissible limit of 2.0 g/test. The regulation will be implemented by the end of 2016.

(4) On-Board Diagnostics (OBD) System

☐Current Motorcycle OBD System

- A motorcycle OBD system that monitors malfunctions caused by a short-circuit or open electric circuits and alerts the driver has been established in Japan.
- It takes several years to prepare additional measures, including monitoring system of fuel injection correction, ISO-conformed connectors for communication off-board, and modification of the malfunction warning lamp. For allowing due time for manufacturing and technical development, the application of new OBD equipment should be at the same as the forthcoming tailpipe emission regulation.

	Items
Already Developed	Open faults of sensors in malfunction, (incl. air pressure sensor, intake pressure sensor, intake air temperature sensor, water temperature sensor, throttle position sensor, cylinder sensor, crankshaft angle sensor, O2 sensor, O2 sensor heater, primary ignition system, air injection system, etc.), release of alert after recovery, malfunction information storage and functional confirmation at the start
To be developed	Monitors of malfunction by fuel injection adjuster, ISO connectors for communication off-board, change of the malfunction alert lamp

Malfunction Alert

- Regarding the OBD II that monitors malfunctions caused not only by a short-circuit or open electric circuits but also by deterioration of systems, components or units, there remain technical difficulties in applying the OBD on PVs to motorcycles.

<Examples of Technical Difficulties>

- Monitoring Catalyst Deterioration: While deterioration is detected by the behavior of O2 sensor signal for PVs, the motorcycle catalyst volume is much less than that of PVs and hence the signal behavior of a deteriorated catalyst is different from PVs.
- Monitoring Misfire: While the misfire is detected by fluctuation of per cycle rotation for PVs, the one for motorcycle is sensitive to the fluctuation of road surface due to the smaller size and volume. In addition, the engine speed of motorcycle in the actual driving is faster than PVs and thus difficult to detect the per cycle rotation.
- Leakage of Evaporative Emission: Due to the larger variation in driving behavior, motorcycle is more sensitive to fuel sloshing than PVs and thus difficult to detect the leakage of evaporative emission.

[Recommendation]

- The OBD equipment that monitors malfunctions caused by a short-circuit or open electric circuits is now mandated. The implementation will occur by the end of 2016.
- Regarding the OBD II that monitors malfunctions caused by deterioration of systems, components or units, it is difficult to determine the validity at this point and will be considered once the technical prospect is confirmed in the future.

(5) E10 Gasoline Fuel for Motorcycles

- Current measures for tailpipe emission reduction is based on the feedback control for theoretical air-fuel ratio. The ratio of oxygen content within the fuel makes little difference on the emission.
- From the technical aspects, manufactures consider that there is no problem concerning emission reduction measures when using E10 gasoline fuel.
- Likewise in four wheelers, motorcycles shall be considered as conforming to the gasoline tailpipe emission regulations at the rate between E0 and E10, regardless of the type of fuel they use. As for the existing fuel evaporative emission regulations, setting E10 as test fuel shall be considered as conforming to the regulation in consideration of permeation of ethanol in the fuel tube.

[Recommendation]

- E10-compatible gasoline motorcycle shall meet the forthcoming tailpipe regulation as well as the evaporative emission regulation.
- They shall also meet the gasoline tailpipe emission regulations at the rate between E0 and E10, regardless of the type of fuel they use.
- Further, they shall meet the existing fuel evaporative emission regulations with E10 regarding the permeation of ethanol in the fuel tube.

Discussion after the 11th Report

- The Expert Committee on Motor Vehicle Emissions had a meeting on 14th March, 2013 and launched the consideration for the forthcoming report.
- One of the agendas is the next emission standard for motorcycles, including harmonization of global technical regulations discussed by IEPPR informal group and the next permissible limit target in consideration of EURO 5.

<Reference> Motorcycle Emission Regulations in Japan

<table>
<tr><th>Items</th><th>Current</th><th>2016 Standard</th></tr>
<tr><td>Tailpipe Emission (Mode)</td><td>• Cycle: WMTC Phase 2
• Limit Values (g/km)
<table><tr><th></th><th>THC</th><th>CO</th><th>NOx</th></tr><tr><td>CC ≤ 125 ccm</td><td>0.45</td><td>2.2</td><td>0.16</td></tr><tr><td>125 ccm < CC</td><td>0.27</td><td>2.62</td><td>0.21</td></tr></table></td><td>• Cycle: WMTC Phase 2
• Limit Values (g/km)
<table><tr><th></th><th>THC</th><th>CO</th><th>NOx</th></tr><tr><td>Class 1</td><td>0.30</td><td>1.14</td><td>0.07</td></tr><tr><td>Class 2</td><td>0.20</td><td>1.14</td><td>0.07</td></tr><tr><td>Class 3</td><td>0.17</td><td>1.14</td><td>0.09</td></tr></table></td></tr>
<tr><td>Tailpipe Emission (Idling)</td><td>• CO: 3%
• HC: 1,600ppm for not exceeding 125cc
1,000ppm for exceeding 125cc</td><td>←</td></tr>
<tr><td>Crankcase Emission</td><td>• No emission is required.
• Design requirement only (No test requirement)</td><td>←</td></tr>
<tr><td>Range / CO_2</td><td>No requirement</td><td>←</td></tr>
<tr><td>OBD</td><td>No requirement</td><td>• OBD system monitoring malfunctions caused by a short-circuit or open electric circuits and alerting is required.
• Details are under consideration.</td></tr>
</table>

<table>
<tr><th>Items</th><th>Current</th><th>2016 Standard</th></tr>
<tr><td>Durability Test</td><td>• Test cycle is stipulated by Enforcement Procedure for Motor Vehicle Type Certification in Japan
• Driving Length (km)<table><tr><th></th><th>Length</th></tr><tr><td>CC ≤ 50ccm</td><td>6,000km</td></tr><tr><td>50 ccm < CC ≤ 125ccm</td><td>8,000km</td></tr><tr><td>125ccm < CC</td><td>24,000km</td></tr></table></td><td>←</td></tr>
<tr><td>Evaporative Emission</td><td>No Requirement</td><td>• 2.0g/test
• Test method is based on US CARB SHED Test.
• Details are under consideration.</td></tr>
<tr><td>Test Fuel</td><td>Test Fuel Quality is stipulated to keep the representativeness of market fuel in Japan.</td><td>←</td></tr>
</table>

Thank you !

Ministry of the Environment, JAPAN