UNITED NATIONS **E**

Economic and Social Council

Distr.
GENERAL

ECE/TRANS/WP.29/GRPE/2009/4
31 October 2008

Original: ENGLISH
ENGLISH AND FRENCH ONLY

ECONOMIC COMMISSION FOR EUROPE

INLAND TRANSPORT COMMITTEE

World Forum for Harmonization of Vehicle Regulations

Working Party on Pollution and Energy

Fifty-seventh session
Geneva, 13-16 January 2009
Item 4 of the provisional agenda

GLOBAL TECHNICAL REGULATION No. 2 ON THE WORLD-WIDE HARMONIZED MOTORCYCLE EMISSION TEST CYCLE

Report on national / regional legislation on pollutant emissions for motorcycles and data collection from emission tests as a basis for the discussion about the introduction of performance requirements into global technical regulation No. 2

Submitted by the expert from Germany [1]

The text reproduced below was prepared by the expert from Germany to summarize available information and data concerning the introduction of performance requirements into global technical regulation (gtr) No. 2 on the Worldwide harmonized Motorcycle emission Test Cycle (WMTC), following the adoption of the formal proposal ECE/TRANS/WP.29/AC.3/19 by the Executive Committee (AC.3) of the 1998 Agreement.

[1] In accordance with the programme of work of the Inland Transport Committee for 2006-2010 (ECE/TRANS/166/Add.1, programme activity 02.4), the World Forum will develop, harmonize and update Regulations in order to enhance performance of vehicles. The present document is submitted in conformity with that mandate.

1. INTRODUCTION

After the establishment into the Global Registry of gtr No. 2 in June 2005, the work on Stage 2 of the World-wide harmonized Motorcycle emission Test Cycle (WMTC) started. One of the issues for consideration in Stage 2 of WMTC was the introduction of performance requirements. The informal group was mandated by AC.3 (ECE/TRANS/WP.29/AC.3/19) to collect data and prepare information as a basis for the discussion.

With the status report (informal document No. GRPE-52-6) to the Working Party on Pollution and Energy (GRPE) in June 2006, the WMTC informal group recommends focusing on only limit values in Stage 2. The discussion about the worldwide harmonization of other performance requirements like durability, off cycle emissions or evaporative emissions, should be postponed to a subsequent Stage 3.

In line with the 1998 Agreement, Contracting Parties are preparing proposals for the introduction of gtr No. 2 as an alternative to the existing national/regional legislation. This set of limit values is the basic information about the current legal situation regarding WMTC application. In parallel, the International Motorcycle Manufacturers Association (IMMA) has collected comparative data and test results for a correlation study, based on technology and regulations that will be in use/force in August 2006. This can be the basis for further discussion by Contracting Parties of a possible harmonization of limit values, aiming on a timeframe of 2010 – 2012.

2. EXISTING NATIONAL / REGIONAL LEGISLATION (POLLUTANT EMISSIONS) FOR MOTORCYCLES

The following tables give only a rough summary of the limit values. More detailed information about some of the national legislation can be found in the ANNEX of informal document No. GRPE-56-11. The tables below do not include mopeds (< 50 ccm), so "all" means > 50 ccm.

2.1. China

cycle	classification	stage (year/month)	CO g/km	HC g/km	NOx g/km	HC+NOx g/km
ECE R40	all	2004	5.5	1.2	0.3	-
ECE R40 (cold)	< 150 ccm	2007/8	2.0	0.8	0.15	-
ECE R40 + EUDC (max. 90 km/h)	> 150	2007/8	2.0	0.3	0.15	-

Note: "ECE R40" means according to UNECE Regulation No. 40.

2.2. European Union (EU)

cycle	classification	stage (year/month)	CO g/km	HC g/km	NOx g/km	HC+NOx g/km
ECE R40	< 150 ccm	2003/4	5.5	1.2	0.3	-
ECE R40	> 150 ccm	2003/4	5.5	1.0	0.3	-
ECE R40 (cold)	< 150 ccm	2006/7	2.0	0.8	0.15	-
ECE R40 + EUDC	> 150 ccm	2006/7	2.0	0.3	0.15	-

2.3. India

cycle	classification	stage (year/month)	CO g/km	HC g/km	NOx g/km	HC+NOx g/km
IDC	all	2005	1.5	-	-	1.5
IDC	all	2008/10	1.0	-	-	1.0

Note: Durability factor of 1.2 is applicable on above norms for CO and HC+NOx

2.4. Japan

cycle	classification	stage	CO g/km	HC g/km	NOx g/km	HC+NOx g/km
TRIAS/ECE R40	all / 2stroke	1999	8.0	3.0	0.1	-
TRIAS/ECE R40	all / 4stroke	1999	13.0	2.0	0.3	-
TRIAS/ECE R40	< 125 ccm	2008	2.0	0.5	0.15	-
TRIAS/ECE R40	> 125 ccm	2008	2.0	0.3	0.15	

2.5. Korea

cycle	classification	stage	CO g/km	HC g/km	NOx g/km	HC+NOx g/km
ECE R40	all	-	8.0	4.0	0.1	-

2.6. United States of America (USA)

cycle	classification	stage	CO g/km	HC g/km	NOx g/km	HC+NOx g/km
FTP	< 170 ccm	2006	12.0	1.0	-	
FTP	170 - 279	2006	12.0	1.0	-	
FTP	> 280	2006	12.0	-	-	1.4
FTP	> 280	2010	12.0	-	-	0.8

3. STATUS OF TRANSPOSITION OF GTR No. 2 INTO NATIONAL / REGIONAL LEGISLATION

3.1. EU

With directive 2006/72/EC, the EU transposed gtr No. 2 into directive 97/24/EC. Equivalent to Euro 3 (see above paragraph 2.2. above), manufacturers can optionally choose, for type approval purposes, the following limits:

Table: WMTC limits correlated to Euro 3 stage

cycle	classification	CO g/km	HC g/km	NOx g/km
WMTC-old (stage 1)	vmax < 130 km/h	2.62	0.75	0.17
WMTC-old (stage 1)	vmax ≥ 130 km/h	2.62	0.33	0.22

3.2. Japan

Based on emissions tests with motorcycles meeting the latest emission legislation, Japan will establish equivalent limits on WMTC within 2008. Then the procedures for transposition of gtr No. 2 as an option will be started. It can be expected, that the WMTC based limit values are on a similar level as in paragraph 3.1.

3.3. China

China is estimated to follow the EU approach.

3.4. USA

The USA expects to introduce the WMTC as an alternative to the Federal Test Protocol (FTP) with equivalent limits to the present USA emission regulations. After a period of time (which would be determined through the USA rulemaking process), the USA intends to phase out the FTP option and ultimately rely exclusively on the WMTC for motorcycle certification purposes. The timing of USA regulatory action is currently not determined.

3.5. India

In India, consideration for introducing WMTC as alternative to existing Indian regulation is under discussion. According to the 1998 Agreement, article 4, section 4.2., it is stated, that "A global technical regulation may specify alternative non-global levels of stringency or performance, and appropriate test procedures, where needed to facilitate the regulatory activities of certain countries, in particular developing countries". It seems that operating conditions vary from one country to another while some countries focus on commuting and fuel efficiency to provide an economical mode of transport for daily needs, others focus on high acceleration and power (nature of sportive vehicles). Addressing these differing target segments results in a wide variation in engine and drive

train design parameters which in turn results in different levels of pollutant emissions under different driving conditions. In view of the above, an option to chose an alternate set of parameters suited best to the driving conditions prevalent in a country is provided for in article 4, section 4.2. The current proposal with application from 2010 is as follows:

Table: India approach (standstill values) with a special cycle application for class 2.1:

classification	CO g/km	HC + NOx g/km
class 1 & subclass 2-1 */	2.14	1.32
subclass 2-2	2.62	0.92
class 3	2.62	0.55

*/ Following gtr No. 2, vehicles of subclass 2-1 have to run cycle part 1 reduced (cold) and part 2 reduced (hot). Differing from that provision, the Indian approach defines that vehicles of subclass 2-1 have to run cycle part 1 reduced (cold) and part 1 reduced (hot).

4. DATA AND TEST RESULTS

4.1. Test data

A more detailed description and documentation of the data and test results can be found in informal document No. GRPE-56-11. 134 test data sets allow a comparison of the results based on WMTC test cycles and other existing national test cycles. The evaluation resulted in a set of so-called "standstill limit values", which are the values based on the WMTC cycles in order to obtain the same level of severity as the existing national limit values when measured with the existing test cycle.

It should be taken into account that already two versions of WMTC test cycles and classification exist. The version "WMTC-stage 1" is the basis, adopted as gtr No. 2 in 2005. With Amendment 1 to gtr No. 2, slight modifications of the classification (classes 1, 2-1) and the test cycles (part 1, 2 alternatives) had been introduced in 2007 (version "WMTC-stage 2").

Most of the data concern class 3 vehicles and come from the EU Joint Research Centre (JRC) data. For this class, the results are relatively homogenous.

Class 1 and 2 data are more spread around the world. Furthermore, due to differences in market, legislation and technology, one might assume that the test results may vary a lot according to the region. This is why rough data of class 1 and class 2 vehicles were analysed by region. Informal document No. GRPE-56-11 shows figures with results distinct for vehicles and regions for class 1 and for class 2 vehicles.

For class 1 vehicles, the updated database contains 47 class 1 motorcycles. For 26 of these motorcycles, measurement values are available for the Euro 3 cycle as well as for the WMTC cycle. The vehicle numbers are chosen in such a way that the regions of China, Japan, India and Europe appear in different colours.

The class 2 vehicle database is still smaller than for the other classes, even if some new vehicles have been added. The whole sample consists of 29 vehicles, 16 of them belonging to class 2-1 and 13 belonging to class 2-2. For all of them, results for the WMTC cycle exist, but for the Euro 3 cycle results are available for 20 vehicles. Concerning the regions, it must be mentioned that European data is completely missing and that class 2-2 consists of 4 Japanese and 3 Indian vehicles only and 3 vehicles from Europe.

4.2. Evaluation of the test results - standstill limit values

4.2.1. Explanation of the standstill limit values

When changing from one test cycle to another, the first question to be resolved when thinking about new limit values is: "What would the existing limits look like if adjusted to fit the new test cycle?" The answer to this question is, the "standstill value".

Assuming that tests are done with the same vehicle under the same general test conditions, the standstill value is calculated with the following formula:

$$L_{wmtc} = \frac{L_e \text{ x } R_{wmtc}}{R_e}$$

where:

L_{wmtc} = the limit value for the WMTC test cycle
L_e = the Limit value with the existing cycle
R_{wmtc} = the test result with the WMTC cycle
R_e = the test result with the existing test cycle

How the resulting data cloud is analysed depends on the objectives. There are many statistical methods for finding out the standstill ratio. For example, the JRC uses the method of taking the average of the ratios for each vehicle tested. In what follows, the IMMA analysis uses a regression line to establish the trend. Such an approach means that some vehicles that would pass the existing test and limit values would not do so with the new limit values. The linear regression method assumes that there is a linear relationship between the emission results of the two cycles. Where such a relation does not exist, the results obtained will be illogical tending to be irrational. Whether the linear relationship exists or not can easily be made out by comparing the coefficient of regression (R^2), which should be more than about 0.85.

The most important determinant of the comparison is the sample that is used to carry out the study. For example, IMMA's analysis imposed a filter on the data in order to eliminate vehicles with a technology that would not be useable for a future reduction in limit values. The data of vehicles on Euro 3 cycle exceeding the Euro 2 limits were discarded. A different basis for the comparison has been used by past and ongoing regional/national studies, such as that carried out by the EU.

Factors that will influence the results include:

(a) the proportion of the different classes of vehicle in the sample: e.g. a sample with a high concentration of class 3 vehicles will not necessarily adequately reflect the situation for class 1 vehicles,

(b) the design concept prevalent in the different markets will make it difficult to combine the results, e.g. a design based on fuel economy will not combine well with a design based on sports performance,

(c) the reference fuel used.

All these factors should be taken into account when considering the results and standstill values presented below.

4.2.2. IMMA Study on standstill limit values

Country / Region	China				EU				India		Japan				USA		
Stage (current)	CHN-2				EU-3				BS-II		JPN-2				EPA-Tier1		
Limit values (g/km)	CO	HC		NOx	CO	HC		NOx	CO	HC+ NOx	CO	HC		NOx	CO	HC+ NOx	
		<150 ccm	≥150 ccm			<150 ccm	≥150 ccm					<125 ccm	≥125 ccm			<170 ccm	≥170 ccm
	5.5	1.2	1.0	0.30	2.0	0.8	0.3	0.15	1.5	1.5	2.0	0.5	0.3	0.15	12	1.0	1.4
Step-1. 2004 data	-	-	-	-	2.42	0.79	0.34	0.20	-	-	3.29	0.47	0.35	0.31	17.0	1.27	1.77
Step-2. All data	4.48	0.60	0.54	0.29	2.82	0.63	0.37	0.18	2.65	1.80	2.54	0.39	0.27	0.31	19.3	1.29	1.77
Step-2. EU-2 filter	5.55	0.76	0.65	0.34	2.43	0.68	0.29	0.18	-3.17	2.02	1.88	0.42	0.25	0.21	22.9	1.43	2.00

4.2.3. India study - class wise - standstill limit values

More background information can be found in informal document No. GRPE-56-11 (Annex G).

Correlation	Data source	Classes	Data considered	No of data points	CO		THC		Nox		HC + Nox	
					R square	SS (g/km)	R square	SS (g/km)	R square	SS (g/km)	R square	SS (g/km)
EU3 - vs WMTC	All regions combined	All class together	All data	111	0.660	2.824	0.610	0.626*	0.798	0.180		
								0.367**				
			EURO 2 filter	59	0.504	2.432	0.742	0.683*	0.712	0.176		
								0.290**				
		CLASS 1	All data	43	0.769	2.307	0.804	0.494	0.841	0.147		
			with EURO filter	26	0.764	2.021	0.842	0.574	0.753	0.156		
		Class 2-1	All data	10	0.394	3.206	0.829	0.409*	0.957	0.207		
								0.257**				
			with EURO filter	5	0.162	4.413	0.654	0.543*	0.914	0.184		
								0.250**				
		Class 2-2	All data	10	0.750	2.860	0.895	0.589*	0.635	0.186		
								0.298**				
			with EURO filter	4	regression not possisble		0.960	0.476*	0.698	0.189		
								0.225**				
		CLASS 3	All	48	0.910	2.542	0.892	0.350	0.833	0.214		
			with EURO filter	24	0.839	2.416	0.824	0.333	0.726	0.199		
	INDIA	All class together	All data	17	0.290	2.307	0.950	0.714*	0.766	0.198		
								0.281**				
			EURO 2 filter	8	0.019	1.832	0.657	0.599	0.188	0.254		
		CLASS 1	All	11	0.740	1.829	0.995	0.717	0.915	0.201		
			with EURO filter	6	0.588	1.788	0.895	0.685	0.527	0.232		
		Class 2-1	All data	3	regression not possisble		1.000	0.929*	0.891	0.217		
								0.273**				
			with EURO filter	1	regression not possisble							
		Class 2-2	All data	3	0.593	3.069	regression not possisble		0.479	0.205		
			with EURO filter	1	regression not possisble							
		CLASS 3	All	1	regression not possisble							
	ACEM	All class together	All data	38	0.887	2.559	0.860	0.783*	0.804	0.227		
								0.323**				
			EURO 2 filter	15	0.759	2.483	0.835	0.748*	0.659	0.209		
								0.282**				
		CLASS 1	All	1	regression not possisble							
			with EURO filter	1	regression not possisble							
		Class 2-1	All data	0	regression not possisble							
			with EURO filter		regression not possisble							
		Class 2-2	All data	3	regression not possible		0.795	0.443	regression not possible			
			with EURO filter	0	regression not possisble							
		CLASS 3	All	34	0.903	2.632	0.906	0.300	0.809	0.230		
			with EURO filter	14	0.803	2.529	0.829	0.320	0.622	0.208		
EU3 - vs WMTC	CHINA	All class together	All data	31	0.717	3.037	0.889	0.480*	0.720	0.143		
								0.326*				
			EURO 2 filter	14	0.477	2.138	0.837	0.557*	0.485	0.141		
								0.280**				
		CLASS 1	All	26	0.730	3.003	0.905	0.495	0.760	0.136		
			with EURO filter	14	0.477	2.138	0.837	0.558	0.485	0.141		
		Class 2-1	All data	5	0.656	2.755	0.873	0.406*	0.616	0.177		
								0.260**				
			with EURO filter	1	regression not possisble							
		Class 2-2	All data	0								
			with EURO filter	0								
		CLASS 3	All	0								
			with EURO filter	0								
	JAPAN	All class together	All data	18	0.837	2.351	0.769	1.019*	0.885	0.162		
								0.358**				
			EURO 2 filter	16	0.860	2.429	0.860	0.497*	0.770	0.165		
								0.338**				
		CLASS 1	All	5	0.885	2.453	0.982	0.578	0.982	0.136		
			with EURO filter	5	0.885	2.453	0.982	0.578	0.982	0.136		
		Class 2-1	All data	2	regression not possisble							
			with EURO filter	2	regression not possisble							
		Class 2-2	All data	4	0.968	2.368	0.957	0.328	0.894	0.149		
			with EURO filter	NR			0.393	0.382	0.991	0.102		
		CLASS 3	All	8	0.828	2.684	0.775	0.418	0.884	0.177		
			with EURO filter	6	0.917	2.402	0.930	0.378	0.854	0.194		
	US	All class together	All data	6	0.962	2.094	0.981	0.159	0.979	0.143		
			EURO 2 filter	4	0.859	2.070	0.911	0.372	0.980	0.184		
		Class 1		0								
		Class 2-1		0								
		Class 2-2		0								
		CLASS 3	All	6	0.962	2.094	0.981	0.159	0.979	0.143		
			with EURO filter	4	0.859	2.070	0.911	0.372	0.980	0.184		
INDIA vs WMTC	INDIA	All class together		23	Regression not possible						Regression not possible	
		Class 1		11	0.378	2.957	No separate norm		No separate norm		0.492	2.019
		Class 2-1		8			No separate norm		No separate norm		0.709	1.513
		Class 2-2		3			No separate norm		No separate norm		Regression not possible	
		Class 3		1								
JAPAN vs WMTC	JAMA	ALL		48	0.601	2.543	0.876	0.270	0.398	0.310		
		class 1		9	0.845	2.236	0.962	0.471*	0.717	0.126		
								0.274**				
		class 2-1		2	Regression not possible		Regression not possible		Regression not possible			
		CLASS 2-2		7	0.759	3.088	0.984	0.413*	0.974	0.222		
								0.259**				
		CLASS 3		30	0.539	2.770	0.848	0.290	0.326	0.354		
US		ALL		19	0.920	19.288	0.929	1.266	No separate norm		0.846	1.773

* : ≤ 150cc
**: > 150cc

The Indian analysis has been carried out separately for each class and for each region. In the case of Euro 3-WMTC correlation, the analysis has been carried out with all data, and also applying Euro 2 filter.

Comments from India:

(a) Euro-WMTC data points of 111 available include India's 18 and Chinese 31 vehicles, which do not reflect proper correlation, as these vehicles are not tuned for compliance to Euro 3. Indian data is based on Indian drive Cycle (IDC). Relating this data from IDC to Euro 3 norms and then equating to WMTC equivalent values does not reflect a correct correlation.

(b) The analysis of data on Indian motorcycles of Class 2-1, show abnormally high standstill values for CO, which are not justifiable. India had expressed these reservations in the Fundamental Element Group (FEG) meeting, held in Ann Arbor on 20-21 November 2007, while accepting the compromise formula. Indian experts are now convinced that Part 2 (reduced speed) cycle is not suitable for India and similar countries, as the operating conditions in such regions focus on commuting and fuel efficiency, rather than high acceleration and power.

(c) Comparative emission traces, highlights the abnormal increase of CO emissions, when the same motorcycle is tested on part 2 (reduced speed) cycle compared to part 1 (reduced speed) cycle. This explains the reason for the abnormal CO values.

5. COMMENTS AND CONCLUSIONS

(a) In some of the WMTC classes (e.g. class 2-1) the database is poor because of the low number of tests conducted. The results should not be taken as exact figures, but can show trends.

(b) A difference in national / regional legislation exists concerning NOx and HC. In some cases, the limits are separated and sometimes combined (see paragraph 2.). The reason for separate limits may be a focus on NOx controlling. Countries like India, focussing more on fuel consumption and CO2 emissions, prefer a combined limit value. USA also follows a combined HC+NOx.

(c) Harmonisation of reference fuel is an important condition for the introduction of harmonised limit values, because of the influence on the results of emission tests.

(d) A comparison of the level of limit values from national / regional legislation is limited because of the following reasons:

  (i) different classification,

  (ii) motorcycles may be designed for different purposes, like high performance or low fuel consumption,

  (iii) engines are designed to meet the existing limit values under the special test conditions like cycle, cold/warm-start, reference fuel.

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