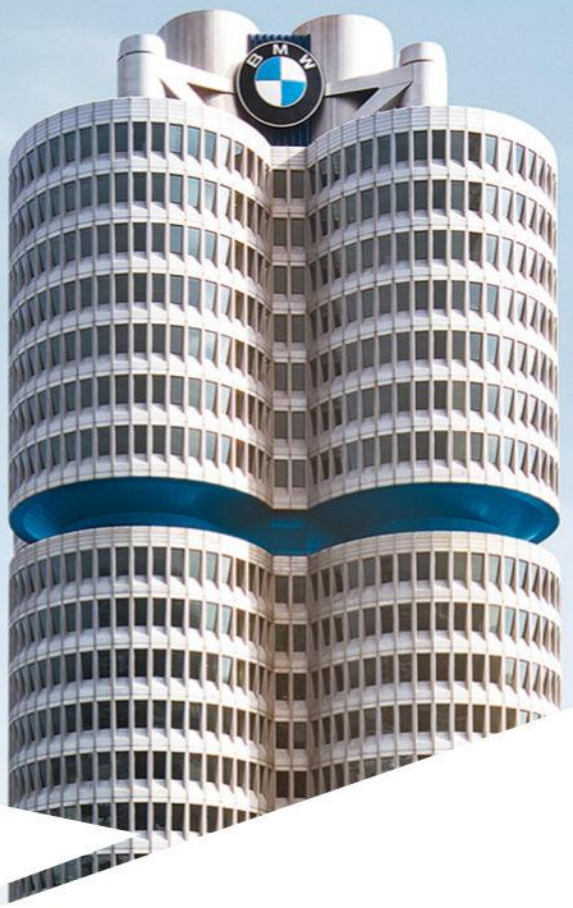
draft

WLTP ROAD LOAD IMPROVEMENTS

IDENTIFIED AMBIGUITIES AND PROPOSALS TO RESOLVE



BMW, Lueginger I 11.04.2017

BMW GROUP

THE NEXT 100 YEARS

Rolls-Royce Motor Cars Limited

CONTENT
LIST OF PROPOSALS

draft

1. Low Temperature Taskforce – Annex 4 – road load at low temperature
2. Annex 4 – Clarification of speeds for wind tunnel measurements
3. Annex 4 – Repeatability and maintenance of road load measurement equipment
4. Annex 4 – Location of payload
5. n/v homogenous definition (in Annex 6)
6. n/v reference, definition of main driven axle (in Annex 7)
7. Improvement of family definitions (general part, Annex 4 and 7)
   - Decoupling of road load family - Limitation to method be be removed
   - Interpolation range and extrapolation
8. Definition of mass in running order

WLTP ROAD LOAD – ANNEX 4 ISSUES
ROAD LOAD AT LOW TEMPERATURES

draft

R83, -7° test

The requirements of Appendix 1 to Annex 4a to this Regulation apply. The dynamometer shall be adjusted to simulate the operation of a vehicle on the road at 266 K (-7 °C). Such adjustment may be based on a determination of the road load force profile at 266 K (-7 °C). Alternatively the driving resistance determined according to Appendix 7 to Annex 4a to this Regulation may be adjusted for a 10 per cent decrease of the coast-down time. The Technical Service may approve the use of other methods of determining the driving resistance.

Europe, 14° test "ATCT"

3.4.1. Road load and dynamometer settings shall be as specified in Sub-Annex 4.

To take account of the difference in air density at 14 °C when compared to the air density at 20 °C, the chassis dynamometer shall be set as specified in paragraphs 7. and 8. of Sub-Annex 4 with the exception that f_{2_TReg} from the following equation shall be used as the target coefficient C_t.

$f_{2\_TReg} = f_2 * (T_{ref} + 273)/(T_{reg} + 273)$

Method	for 14°	for -7°	aerodynamics	tires and drivetrain
#1: -7° test approach	+2% for f0f1f2	**+10% for f0f1f2**	Aero is considered correctly by the change of air density.	On a 1-axis dynamometer the cold start effect of the tires of the still standing axle is not considered.
#2: method in ATCT test	**+2% for f2**	+10% for f2		Chassis dyno setting is done with warmed up vehicle (tires, drivetrain), while the vehicle is started cold. So f0f1 should not be considered.

- There are two ways to estimate the road load. Method 2 will be perfectly correct on a 2-axis dyno and has small limitations on a 1-axis dynamometer regarding one axis tire warm up. Method 1 is maybe overestimating the effect, especially in a 2-axis situation.
- Measuring road load at -7° is not possible or reasonable. The actual value will never be known.
- As the precise value cannot be determined, the current definition for the Type VI test is fine as well as moving to the ATCT method.
- The adaptation to 14°coming from 20° is small, so errors have a small effect. Additionally the correction function is well-known from coast down testing within that temperature range. Using that down to -7° is difficult. As a consequence it should be stated clearly, that a precise CO_2-result or electric range is not achievable. But for emission check a good road load estimation is enough and a simple approach will work.

WLTP ROAD LOAD – ANNEX 4 ISSUES
SPEEDS AND WIND TUNNEL MEASUREMENT

draft

– There are some misunderstandings on speeds with the wind tunnel measurement.

– The target, that should be reflected in the GTR text, is presented here:

reference speed	wind tunnel speed	vehicle with movable aero parts, e.g. spoiler		
20 kph	140 kph	position 1	cd*A = 0.567	measurement #1 for pos. #1
30, 40, 50 kph	140 kph	position 1	cd*A = 0.567	
60 kph	140 kph	position 1	cd*A = 0.567	
70 kph	140 kph	position 2	cd*A = 0.589	measurement #2 for pos. #2
80, 90, … 120	140 kph	position 2	cd*A = 0.589	
130 kph	140 kph	position 2	cd*A = 0.589	

vs.

reference speed	wind tunnel speed	vehicle without movable aero parts		
20 kph	140 kph	only one configuration	cd*A = 0.600	one measurement for that vehicle configuration
…				
…				
…				
130 kph				

Explanations:

– The cd*A value does not depend on the velocity in that area, that is relevant for the WLTC.

– A wind tunnel typically cannot measure at lower speeds, as then the velocity is not constant enough to produce good results. Therefore that 140kph requirement is included in the criteria in the GTR.

– Movable aerodynamic parts are addressed correctly, as every position is to be measured, and then applied to the reference speed, where it is relevant.

WLTP ROAD LOAD – ANNEX 4 ISSUES
MEASUREMENT EQUIPMENT FOR ROAD LOAD DETERMINATION

draft

Method	Test equipment	risks and potential problems	possible solution
All methods	Weighing scales	no periodical check, calibration	Require ISO 9001 ceritification.*
Coast Down	Velocity measurement	no periodical check, calibration	Require ISO 9001 ceritification.*
	Wind measurement on track	no periodical check, calibration	Require ISO 9001 ceritification.*
	On-board anemometry (if any)	no periodical check, calibration, damage during usage	Require ISO 9001 ceritification.* Require additional calibration after improper handling.
	Test track (slope; flat and even)	frost damage, earthquake	Check of all criteria, that might have been influenced: - after winter season, if T was <0°C - after a major environmental event (e.g. earthquake).
Torque Meter	Torque meters	no periodical check, damage during usage	Require ISO 9001 ceritification.* Require additional calibration after improper handling.
Wind tunnel method	Wind tunnel	no periodical check, calibration	Require ISO 9001 ceritification.* Require validation with a golden vehicle after major maintenance.
	Flat belt	no periodical check, calibration	Require ISO 9001 ceritification.* Require additional calibration after major maintenance.
	Chassis dyno	should be covered by emission measurement requirements	

- Following the proposal from Japan, just relying on "good engineering judgement" shall not be the only basis for the correct maintenance of the testing equipment. As a consequence proposals are provided, how that could be solved.
- * ISO 9001 requires a periodical calibration and verification of a measurement tool. Alternatively a calibration prior to each test is possible as well.

WLTP ROAD LOAD – ANNEX 4 ISSUES LOCATION OF PAYLOAD

draft

Identified issue:

– While for the driver-mass the position is clear, the position of the payload (25 kg and the mass representative of the vehicle load) is not defined.

Justification:

– As "the load" could be everything like a front-seat passenger, luggage in a front boot or rear boot, it is easier and more transparent to keep the already used definition for the weight distribution.

– As measurement equipment is typically located at the front seat, it also practical in terms of road load testing.

– As the influence of that issue is very small anyway, a very precise adjustment would be just burdensome, especially as also changed by the fuel consumption during the test. Therefore the word "approximately" is added.

– the value shall be recorded for any in-use testing or for calculation purpose (interpolation method).

3.2.6.	"*Mass of the driver*" means a mass rated at 75 kg located at the driver's seating reference point.
3.2.25.	"*Test mass of the vehicle*" means the sum of the actual mass of the vehicle, 25 kg and the mass representative of the vehicle load.
3.2.26.	"*Mass representative of the vehicle load*" means x per cent of the maximum vehicle load where x is 15 per cent for category 1 vehicles and 28 per cent for category 2 vehicles.

Text proposal:

Add a new paragraph 2.6. in Annex 4 (paragraph 2 is containing of general definitions of Annex 4):

2.6. The payload mass shall be applied such, that the weight distribution of that vehicle with mass in running order is approximately maintained. The weight distribution of the vehicle with mass in running order shall be recorded.

ANNEX 6
USAGE OF N/V RATIO

draft

Identified issue:

– Japan proposed a clarification of n/v definition (started in Paris 2016). During that improvement of the text, one part was forgotten / missed: The vehicle description in Annex 6.

Justification:

– Align with other parts of gtr.

– Add a tolerance of 1.5%, as the effect is negligible and it makes type approval process easier, as maybe the tire giving the shortest n/v ratio is not available for type approval. 1.5% is also the tolerance for tire manufacturer.

If at the request of the manufacturer the interpolation method is used (see paragraph 3.2.3.2. of Annex 7), an additional measurement of emissions shall be performed with the road load as determined with test vehicle L. Tests on vehicles H and L should be performed with the same test vehicle and shall be tested with the shortest final transmission ratio within the interpolation family. In the case of a road load matrix family, an additional measurement of emissions shall be performed with the road load as calculated for vehicle

Text proposal:

Change one sentence in paragraph in 2.3.1. of Annex 6

Tests on vehicles H and L should be performed with the same test vehicle and shall be tested with the shortest n/v ratio ±1.5% tolerance within the interpolation family.

ANNEX 7
CLARIFICATION IN N/V CALCULATION

draft

Identified issue:

– If a 4WD vehicle has different tire dimensions at the front a rear axle, it is not clear, which n/v ratio is to be used for family criteria, gearshift calculation, etc.

8. Calculating n/v ratios

n/v ratios shall be calculated using the following equation:

$$\left(\frac{n}{v}\right)_i = (r_i \times r_{axle} \times 60000)/(U_{dyn} \times 3.6)$$

where:

Justification:

– For 2WD vehicles, the non-driven axle is not relevant.

– For 4WD vehicles the power is mainly provided via the main axle of that vehicle. So for the actual n/v ratio that axle is relevant.

Text proposal:

Add a sentence at the end of paragraph 8 in Annex 7:

If U_{dyn} is different for the front and the rear axle, the value of the mainly powered axle shall be applied. On request the responsible authority shall be provided with the necessary information for that selection.

IMPROVEMENTS IN FAMILY DEFINITIONS
LINK BETWEEN ROAD LOAD FAMILY AND A METHOD

draft

Identified issue:

– For some reason the possibility to use different road load families in one interpolation family is linked to a specific method.

Justification:

– That link is not necessary and not intentionally introduced.

– During the development of the "road load delta procedure" it was clear, that having more road load families in an interpolation family is possible, if certain constraints are fulfilled. That constraints and changes are already included an drafted in the gtr.

– Linking that possibility to only one method is not justifiable, as it does not matter, whether that two road load families are derived by method A or B.

L_M according to paragraph 5.1. of Annex 4.

Road load coefficients and the test mass of test vehicle L and H may be taken from different road load families, as long as the difference between these road load families results from applying paragraph 6.8. of Annex 4, and the requirements in paragraph 2.3.2. of this annex are maintained.

Source:

vehicles R and N have identical aerodynamic resistance and if the measured delta appropriately covers the entire influence on the vehicle's energy consumption. This method shall not be applied if the overall accuracy of the absolute road load of the vehicle N is compromised in any way

Text proposal:

Change a sentence in paragraph 2.3.1. of Annex 6:

Road load coefficients and the test mass of test vehicle L and H may be taken from different road load families, as long as the road load difference between the different road load families covers the entire influence on the vehicle's energy consumption due to that differences, and the requirements in paragraph 2.3.2. of this annex are maintained.

IMPROVEMENTS IN FAMILY DEFINITIONS INTER AND EXTRAPOLATION

draft

– How to apply the extrapolation is not clear enough. If there is a range of 27g tested, an extrapolation to the lower end is possible by 3g, but then no extrapolation to the higher end is allowed (max. 30g limit) – and the other way around. But if it is technically possible in each case, that restriction is obviously not reasonable. So maybe we should change that concept.

declared value	option 1	option 2	option 3
High 180 g/km	180 + 3 = 183	180 + 0 = 180	180 + 3 = 183
Low 153 g/km	153 - 0 = 153	153 - 3 = 150	153 - 3 = 150
<= 30g OK	<= 30g OK	<= 30g OK	>30g not OK

declared value	option
High 180 g/km	180 + 3 = 183
Low 153 g/km	153 - 3 = 150
new: <= 27g demand	no further limit (<33g indirectly)

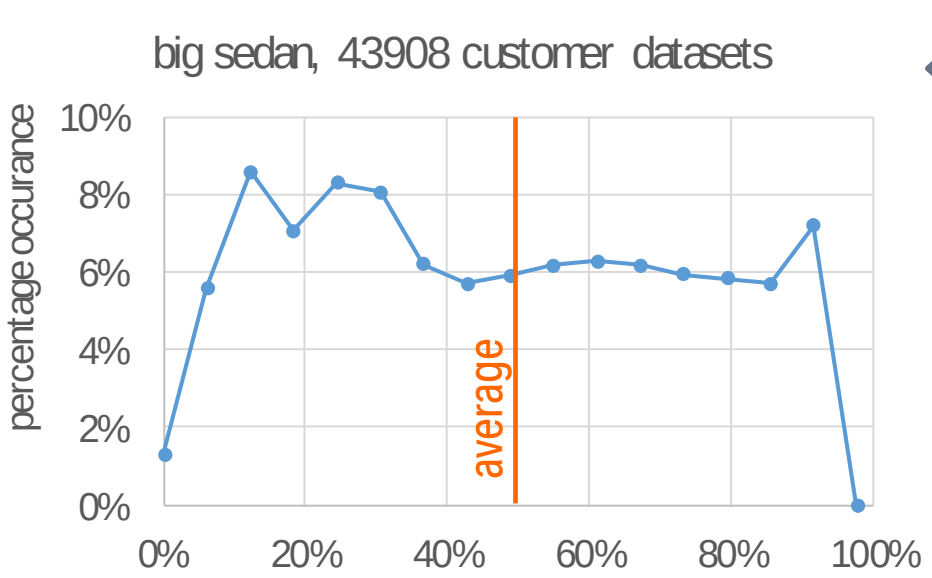
– In that context it appeared, that the 30g limit is often too small. There are validation data showing, that it works at least up to 40g. On the other hand we have already the concept of the mid vehicle for hybrid vehicles. So improvements are possible.

As this is very fundamental, it cannot be handled as a short proposal to be resolved quickly.

If it is generally supported to develop that two issues, more detailed proposals will be prepared.

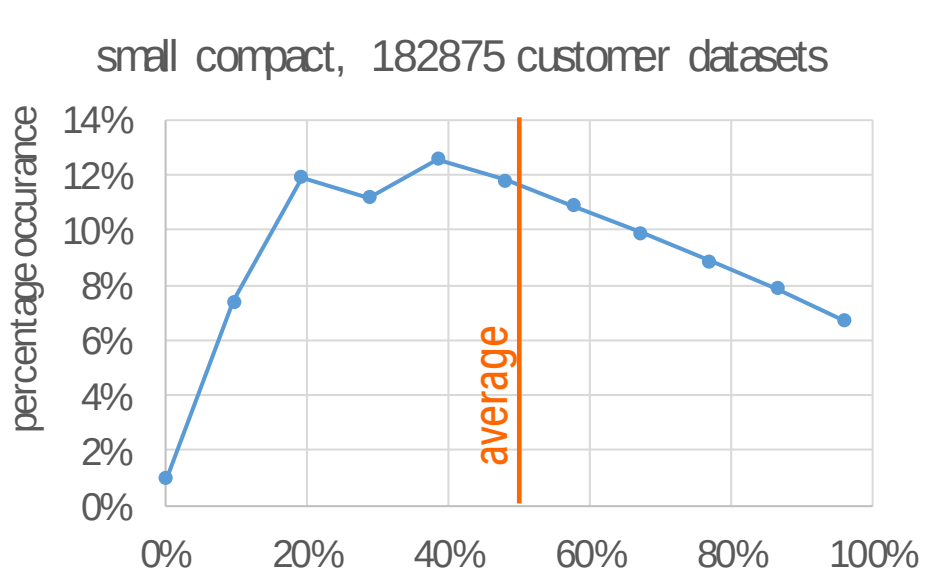
IMPROVEMENTS IN FAMILY DEFINITIONS
DEFINITION OF MASS IN RUNNING ORDER

draft



Graph show data from 2 different vehicles.

Data show 47% average for sedan, 50% for the compact vehicle.



3.2.5. "*Mass in running order*" means the mass of the vehicle, with its fuel tank(s) filled to at least 90 per cent of its or their capacity/capacities, including the mass of the driver, fuel and liquids, fitted with the standard equipment in accordance with the manufacturer's specifications and, when they are fitted, the mass of the bodywork, the cabin, the coupling and the spare wheel(s) as well as the tools.

- Current definition requires >90% liquids. That is not representative of real world situation.
- It is welcomed, to complement with independent data.
- **A value of ~55% for liquids seems more appropriate.**

THANK YOU!