WLTP-22-11e
Appendix_02a

Japan proposals on Wind tunnel method

April, 2018 WLTP IWG @ Ispra
Japan

Review of proposals by Japan (1/2)

■ Background of proposal (First raised in April 2017 WLTP IWG @Bern, See WLTP-18-19e for details)

- In GTR 15 Annex 4, measuring speed(s) for Wind tunnel method was unclear.
- Japan found that the vehicles without movable aero body parts might also have speed dependent aerodynamic drag.

Discussion Points	Japan Proposal in 2017 (see text proposal for details)
I. Wind tunnel facility requirement criteria	Comply the required criteria at the wind speed points used to measure aerodynamic drags. When measuring Class 1 vehicles, the accuracy of measured force in the x-direction shall be measured with an accuracy of ± 1.25N (1/4 of Class 2 and 3).
II. Measurement numbers and speed range	Measure at two wind speed points. • For Class 1: Lower wind speed point v_{low} to measure aerodynamic drag shall be v_{low} < 80 km/h. Higher wind speed point v_{high} shall be v_{low} + 40 km/h ≤ v_{high} ≤ 150 km/h. • For Class 2 & 3: Lower wind speed point v_{low} to measure aerodynamic drag shall be 80 km/h ≤ v_{low} ≤ 100 km/h. Higher wind speed point shall be v_{low} + 40 km/h ≤ v_{high} ≤ 150 km.
III. Measurement points used in facility approvals vs vehicle homologation	For facility approval measure at all wind speed points which can be used at vehicle homologation. For vehicle homologation, wind speed points combination should be same as facility approvals.

Review of proposals by Japan (2/2)

DP IV: Proposal from Japan

From Dec. 2017 New Issues TF

IV. Calculation of measured results

1. Measure aerodynamic drag f_{Aj} at more than 2 speed points
2. Determine $F_A = (f_{1a} \times v) + (f_{2a} \times v^2)$ from 2 results and 0 at 0kph by using a least square regression.

Proposal A:

A-1. Calculate F_{Aj} at each reference speed point from F_A equation (20kph to 130kph)

A-2. Measure rolling resistance F_{Dj} on CH-DY or on flat belt at each reference speed point

A-3. Calculate $F_j = f_{Dj} + F_{Aj}$ at each reference speed point

A-4. Determine $F = f_0 + (f_1 \times v) + (f_2 \times v^2)$ by using a least square regression

Proposal B:

B-1. Measure rolling resistance f_{dj} on CH-DY or on flat belt at each reference speed point

B-2. Determine $F_D = f_{0d} + (f_{1d} \times v)$ using a least square regression

B-3. Calculate $F = F_D + F_A$ by a least square regression

Proposal A	20kph	…	130kph
Aero drag	F_{A_20kph}	…	F_{A_130kph}
Rolling Resis.	F_{D_20kph}	…	F_{D_130kph}
Road Load	$F_{D\_20kph} + F_{A\_20kph}$	…	$F_{D\_130kph} + F_{A\_130kph}$
Road Load equation	$\boldsymbol{F = f_0 + (f_1 \times v) + (f_2 \times v^2)}$		

Proposal B	Equation
Aero drag	$F_A = (f_{1_a} \times v) + (f_{2_a} \times v^2)$
Rolling Resis.	$F_D = f_{0d} + (f_{1d} \times v)$
Road Load	$\boldsymbol{F = F_D + F_A}$

Currently BMW is checking if BMW can accept Proposal A

BMW comments to "Calculation method" by Japan

From Mar. 2018 New Issues TF draft

ANALYSIS OF JP PROPOSAL ON CD*A DETERMINATION

DP IV: Proposal from Japan

IV. Calculation of measured results

1. Measure aerodynamic drag f_{Aj} at more than 2 speed points
2. Determine $F_A = (f_{1a} \times v) + (f_{2a} \times v^2)$ from 2 results and 0 at 0kph by using a least square regression.

Works in WLTP for H, L and ind?	Works with moveable body parts?	Works in NEDC correlated in EU?
Works for the determination of f0f1f2 for H and L, as they are anyway calculated by each speed point. "ind" not affected, therefore OK as well.	This needs the possibility to weigh cd*A values after the Type I test including a different application in the family.	This is not an ECE issue. But it is necessary to keep WLTP applicable in Europe. The NEDC procedure needs one defined cd*A value.
✓	✗	✗

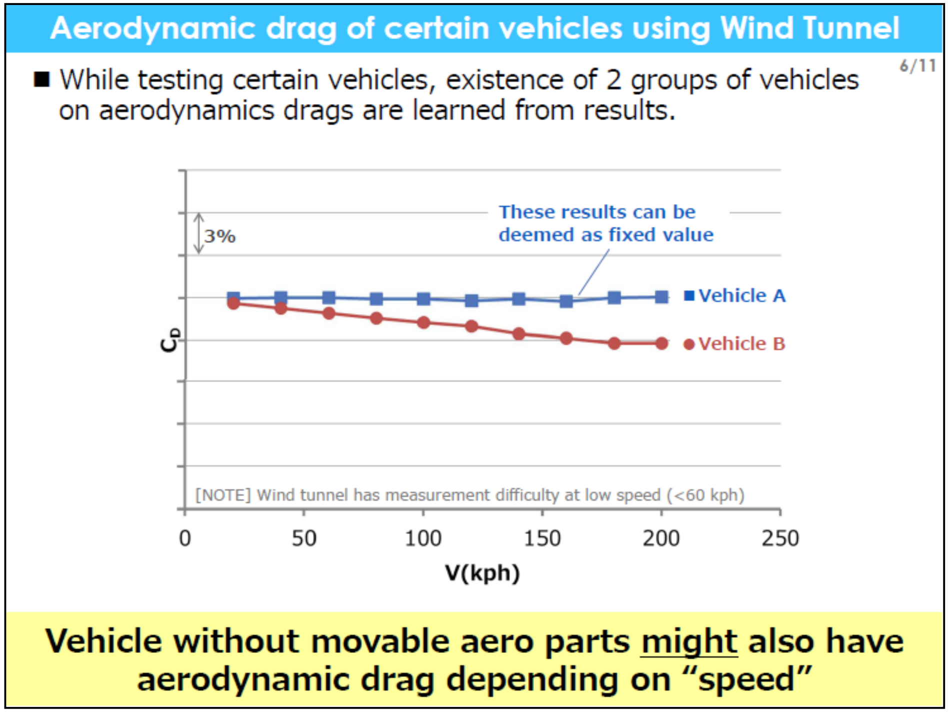
- (1.) Measuring at two wind speeds is supported.
- (2.) The procedure how to use that results cannot be supported, as it does not work under all conditions within the regulation (EU) and with all different technologies available on vehicles (moveable aerodynamic body parts).
- Way forward: It is proposed to determine a (weighted?) average of the cd*A value and use only one value. Additionally there should be the option to use the value of the higher wind speed, if the value of the lower wind speed is within the WLTP tolerance for cd*A (0.015 m²).

BMW had a problem with applying method to movable aero body parts.
BMW proposed to use only one Cd*A value.

Answer to BMW comments by Japan

- Unfortunately, Japan cannot accept having only one Cd*A value, since the speed dependent aerodynamic drag would exist. Japan want them to be reflected to road load.

From WLTP-18-19e



- Japan understand BMW comments that how to apply the calculation method to the movable aero body parts is unclear in both GTR 15 and proposal by Japan.

Japan brought additional proposal for the calculation method to include the movable aero body parts.

Additional Proposal by Japan

For speed dependent movable aero body parts

At each position of parts, measure aerodynamic drag f_{Aj} at 2 wind speed points.

e.g. if there are 3 positions, there will be 6 results.

1. For each position, determine $F_A = (f_{1a} \times v) + (f_{2a} \times v^2)$ from 2 results and 0 at 0kph by using a least square regression.
   e.g. if there are 3 positions, there will be 3 equations, F_{Alow}, F_{Amid}, F_{Ahigh}.
2. Calculate F_{Aj} at each reference speed point from F_A equation (20kph to 130kph)
   e.g. if there are 3 positions and position low applied for 20 to 60 kph, position mid applied for 70 to 120 kph, and position high applied for 130 kph, use F_{Alow} for 20 to 60 kph, use F_{Amid} for 70 to 120 kph, and use F_{Ahigh} for 130 kph to calculate F_{Aj} at each reference speed point.
3. Measure rolling resistance F_{Dj} on CH-DY or on flat belt at each reference speed point
4. Calculate $F_j = F_{Dj} + F_{Aj}$ at each reference speed point
5. Determine $F = f_0 + (f_1 \times v) + (f_2 \times v^2)$ by using a least square regression

	20kph	…	130kph
Aero drag	F_{A_20kph}	…	F_{A_130kph}
Rolling Resis.	F_{D_20kph}	…	F_{D_130kph}
Road Load	$F_{D\_20kph} + F_{A\_20kph}$	…	$F_{D\_130kph} + F_{A\_130kph}$
Road Load equation	$\boldsymbol{F = f_0 + (f_1 \times v) + (f_2 \times v^2)}$		

For other movable aero body parts

(not speed dependent)

Should consult with TA, how to apply.

Thank you for your attention!