

PRESENTATION OF



INTERNATIONAL ORGANIZATION OF MOTOR VEHICLE MANUFACTURERS

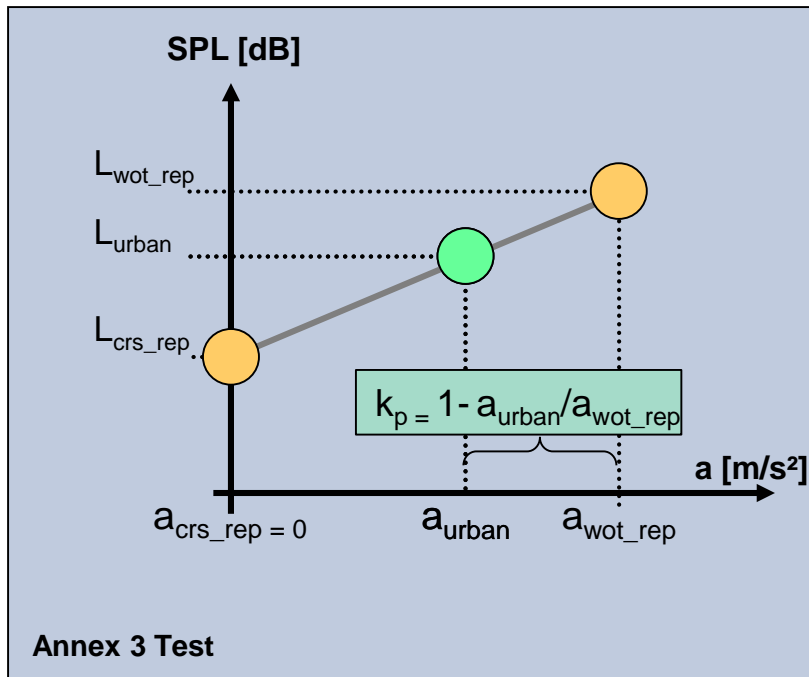
**Technical Background Information
Partial Load Driving Formulae**

In Supplement 4 to UN R51.03

Partial Load Driving

- GRB has adopted in 1/2018 Supplement 4 to UN R51.03 which contains examples for measures acceptable to either prevent downshift or to restrict the acceleration.
- For the time being, the partial load driving was adopted with a restriction, to be only applicable to pure electric vehicles.
 - Contracting parties requested more information on the formulae provided by OICA to calculate from a partial load pass by test to a virtual full load test condition, necessary for the determination of the anchor point for ASEP.
- **This presentation provides considerations and calculation steps for the formulae.**

Partial Load Driving – The Spirit of the Regulation



- **The scope of UN R51.03 Annex 3 is to simulate typical urban driving.**
- According to statistics on urban traffic, normal driving is a partial load acceleration, decided by GRB for a speed of 50 km/h.
- For repeatability and reproducibility, the partial load test was split into a full load acceleration test and a cruise-by test.
 - While the cruise-by test is a very typical and normal driving situation, the full load acceleration test is NOT a typical driving situation.
 - Therefore, the maximum acceleration should be restricted to 2 m/s², an acceleration, which statistically not relevant in urban traffic at speeds around 50 km/h.

$$L_{urban} = L_{wot} - k_p (L_{wot} - L_{crs})$$

where $k_p = 1 - a_{urban} / a_{wot,ref}$

Partial Load Driving – The Spirit of the Regulation

- Modern car designs can lead to the situation, where no transmission setup can be found to provide an acceleration within the acceleration boundaries between a_{urban} and $a_{\text{wot,ref}}$ respectively 2m/s^2 .
- Therefore it should be considered to come back on the original intention, to drive the vehicle at partial load within the acceleration boundaries.

Partial Load Driving For Vehicles Falling under ASEP

- While PEV and serial HEV do not fall under the scope of ASEP, it is necessary to consider the consequences of partial load driving for other vehicle to which ASEP is applicable.
- A partial load test at a_{urban} would mean a direct simulation of the statistical test point.
- Therefore, the partial load test result might be substantially lower compared to the full load acceleration test, especially when the acceleration is close to a_{urban} .
- However, ASEP is an assessment under full load condition.
- Therefore, it is necessary to transfer the partial load result of Annex 3 into a full throttle virtual reference for the anchor point of ASEP under Annex 7

Consideration on the Anchor Point – Sound Level

- When carrying out the Type Approval Test under Annex 3, the test results of the full load acceleration test and the constant speed test are combined by the partial power factor to L_{urban} .

$$L_{\text{urban}} = L_{\text{wot}} - k_P (L_{\text{wot}} - L_{\text{crs}}) \text{ where } k_P = 1 - a_{\text{urban}} / a_{\text{wot,ref}}$$

- If the Type Approval test is carried out under partial load, the test result shall be associated to L_{urban} , as L_{urban} represents the partial load result of the combined full load and constant speed (no load) test.
- For ASEP, the full load test result L_{wot} is taken as reference. If a partial load test is carried out, it is possible to use the above function to calculate the full load reference by using a_{test} , the acceleration achieved during the partial load test.

Calculation Step for the Virtual L_{wot} Reference

- Starting from the L_{urban} calculation scheme and replacing L_{urban} by the partial load test result $L_{partial}$ with an acceleration attest:

$$L_{partial} = L_{wot} - k_P (L_{wot} - L_{crs}) \text{ where } k_P = 1 - a_{test} / a_{wot,ref}$$

- The full load sound level L_{wot} can be determined by resolving the formula for L_{wot} .

$$L_{partial} = L_{wot} - k_P (L_{wot} - L_{crs}) \quad \text{where } k_P = 1 - a_{test} / a_{wot,ref}$$

$$L_{partial} = L_{wot} (1 - k_P) + k_P * L_{crs} \quad \text{where } k_P = 1 - a_{test} / a_{wot,ref}$$

$$L_{wot} = (L_{partial} - k_P * L_{crs}) / (1 - k_P) \quad \text{where } k_P = 1 - a_{test} / a_{wot,ref}$$

Correction for Vehicle Speed v_{BB}

- Under partial load, the vehicle has been tested at a certain transmission setup with a gear ratio leading to $n_{BB,partial}$ at $v_{BB,partial}$. These two values can be reported during the test.
- Under the assumption, that the gear ratio is held constant for the full load test it is possible to determine the vehicle speed under full load by using the reference acceleration $a_{wot,ref}$ for a full load acceleration test with 50 km/h at the microphone line.

$$a_{wot,ref} = ((v_{BB,wot}/3,6)^2 - \underbrace{(50/3,6)^2}_{= 192,9}) / (20 + 2l_{veh})$$

- This formula can be resolved for $v_{BB,wot}$:

$$v_{BB,wot} = 3,6 * (a_{wot,ref} * (20 + 2l_{veh}) + 192,9)^{0,5}$$

Correction for Engine Speed n_{BB}

- Under the assumption, that the gear ratio is held constant for the full load test, the engine speed is proportional to the vehicle speed.

$$\text{T/M ratio } i = \text{constant} = v_{BB,\text{partial}} / n_{BB,\text{partial}} = v_{BB,\text{wot}} / n_{BB,\text{wot}}$$

- From this, it is possible to determine the engine speed $n_{BB,\text{wot}}$ under full load

$$v_{BB,\text{partial}} / n_{BB,\text{partial}} = v_{BB,\text{wot}} / n_{BB,\text{wot}}$$

$$n_{BB,\text{wot}} = n_{BB,\text{partial}} * v_{BB,\text{wot}} / v_{BB,\text{partial}}$$

$$\text{where } v_{BB,\text{wot}} = 3,6 * (a_{\text{wot,ref}} * (20 + 2l_{\text{veh}}) + 192,9)^{0,5}$$

$$n_{BB,\text{wot}} = 3,6 * n_{BB,\text{partial}} * (a_{\text{wot,ref}} * (20 + 2l_{\text{veh}}) + 192,9)^{0,5} / v_{BB,\text{partial}}$$

Conclusion

- It is possible to transpose a partial load test sound level result to a virtual full load reference condition for vehicles falling under the provision of ASEP.
- The transposition uses the same formulae described in Annex 3 of UN R51.03.
- With this approach, it is possible to determine an appropriate anchor point for Annex 7 for all vehicles.
- Partial load test is possible for all vehicles.
- The necessary values for either Slope-Assessment or L_{urban} -Assessment are available.