WLTP-18- 05e Rev1

Cycle / Gearshifting

Status report about the work of the task force on cycle and gearshift issues

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14.04.2017

Remaining open issues

- **Downshifts during decelerations down to standstill,**
- **Round robin test for gearshift calculation tools,**
- **Annex 2, further amendments**
  - **Definition of n_{max}, paragraph 2 (g) of annex 2,**
  - **Additional requirements,**
    - **amendment of paragraph 4 (d),**
    - **Add a new requirement 4 (g).**
- **The new n_{max} in 2 (g) need to be considered in 2 (i), 2 (h), 3.3 and 3.5.**
- **4 (g) resulted from calculations performed within the preparation of the round robin test for the calculation tools.**

Downshifts during decelerations down to standstill

- **This issue was brought up by Nick Ichikawa. He proposed the following modification for final decelerations to standstill of each short trip:**
- **The gear used just before the deceleration starts should be kept with the clutch engaged during the deceleration until the engine speed drops below n_{min_drive}.**
- **For the rest of the deceleration phase either the gear lever shall be set to neutral with the clutch engaged or the gear shall be kept with the clutch disengaged.**

Downshifts during decelerations down to standstill

- **One group member expressed objections, because this would not reflect normal practical use and reminded the group that the use of the 1st gear is already prohibited by the current provisions.**
- **The chairman performed calculations for 25 example vehicles and determined the following parameter for the last "neutral" phase of the 8 short trips of the WLTC:**
  - **Starting vehicles speed,**
  - **Distance driven,**
  - **Duration of this phase.**
- **The results were put in an Excel sheet which was sent to the GSTF members with the request for comments.**

Downshifts during decelerations down to standstill

- **Most critical is the last phase of the short trip of the extra high speed phase.**
- **In all cases the gear lever had to be put to neutral once n_{min_drive} in the highest gear was reached, which could already start at vehicle speeds of 85 km/h.**
- **The corresponding distances could go up to 500 m and the duration could exceed 30 seconds.**
- **So far the chairman got 5 comments from TF members with statements, that this proposal does not reflect practical use.**
- **Since it was not possible to organize a TF meeting or a telco in due time before the IWG meeting, a final decision was not yet made in the TF.**

Downshifts during decelerations down to standstill

- **At 05.04.2017 Nick Ichikawa withdraw his proposal described before, but made the following new proposal:**
- **It is allowed to set higher n_{min_drive} than defined in paragraph 2 (k) indent (c) of Annex 2. The aim is to improve drivability by excluding the low engine speed with high load. It’s obvious that this option is designed for acceleration, not for deceleration.**
- **Since no drivability problem is observed during deceleration, it is more representative to keep the original n_{min_drive} definition during deceleration in any cases.**
- **This proposal was sent to the GSTF but not yet discussed.**

Round Robin tests for GS calculation tools

- **At IWG #16 Christoph Lueginger proposed a round robin test for gearshift calculation tools in order to check the tools as well as the common understanding of the text in annex 2.**
- **The chairman asked the TF members to provide input data of example vehicles for this exercise.**
- **The deadline for the delivery was set to end of March.**
- **Meanwhile datasets of 22 example vehicles were provided by 3 OEMs and JARI. 4 of these vehicles have variants with speed caps or ASM.**
- **The chairman added 6 vehicles intended to cover the whole variation ranges of technical design parameters (e.g. a vehicle with a 10speed gearbox).**

Round Robin tests for GS calculation tools

- Once the ACCESS calculation tool has been amended (see next issue), the amended tool and the example vehicles will be distributed to those participants that use own calculation tools and the RRT will be started.
- The results of the calculations with the different tools will then be collected and compared.
- The start can be expected for end of April and the end of the comparison of the results after the summer break.
- Interim results might be available already for IWG #19.

Further amendments of annex 2

- **The Japanese colleagues provided 3 example vehicles for the round robin test of gearshift calculation tools.**
- **One of these examples could not correctly be calculated with the ACCESS tool (version 31.01.2017) because the design of the full load power curve led to a too low value for n_{max_95} (n_{95_low}).**
- **As a consequence the 2 second rule for acceleration phases (keep a given gear for at least 2 seconds) would lead to higher engine speeds than n_{95_low}.**
- **The vehicle has an extreme wot power curve with n_{rated} of 2000 min^{-1}, but a usable speed range up to 5000 min^{-1}. The vehicle speed at rated engine speed is 63,6 km/h, the engine speed at max. vehicle speed is 4480 min^{-1}.**

Specifications for n_{max}, para 2 (g)

- **The available power for different gears and the required power for constant speed driving are shown in figure 1.**
- **n_{95_low} is 1893 min^{-1} (indicated by the pink line parallel to the x-axis); this leads to the fact that the 2. gear can only be used for just 1 second at t = 538 s and at t = 1030 s.**
- **A similar example is vehicle 78 (a N2 example provided by Japan), whose power curves are shown in figure 2. The 2. gear can only be used for just 1 second at t = 141 s, t = 515 s and t = 1030 s.**

Available and required power vs speed

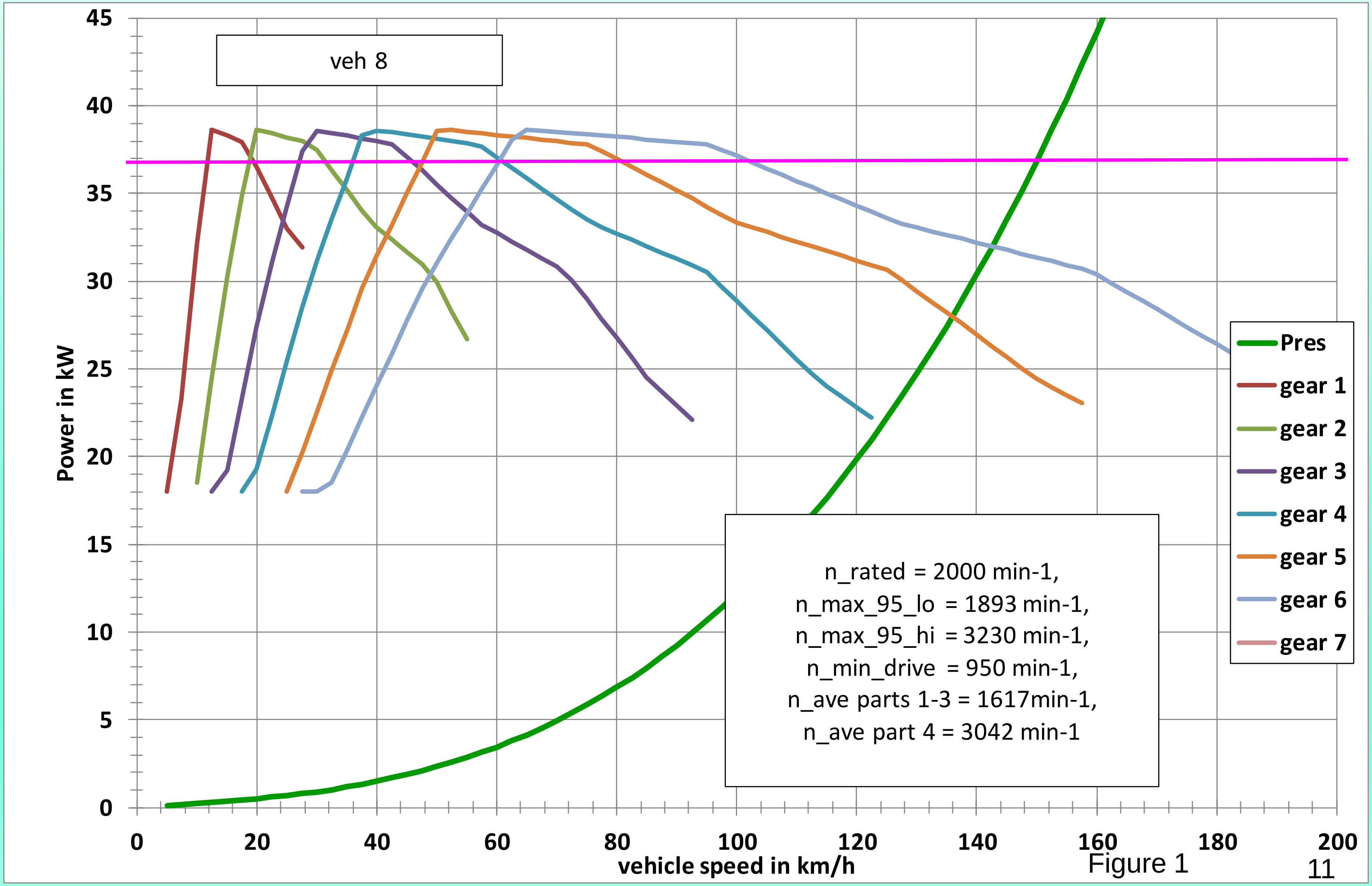

Figure 1

Available and required power vs speed

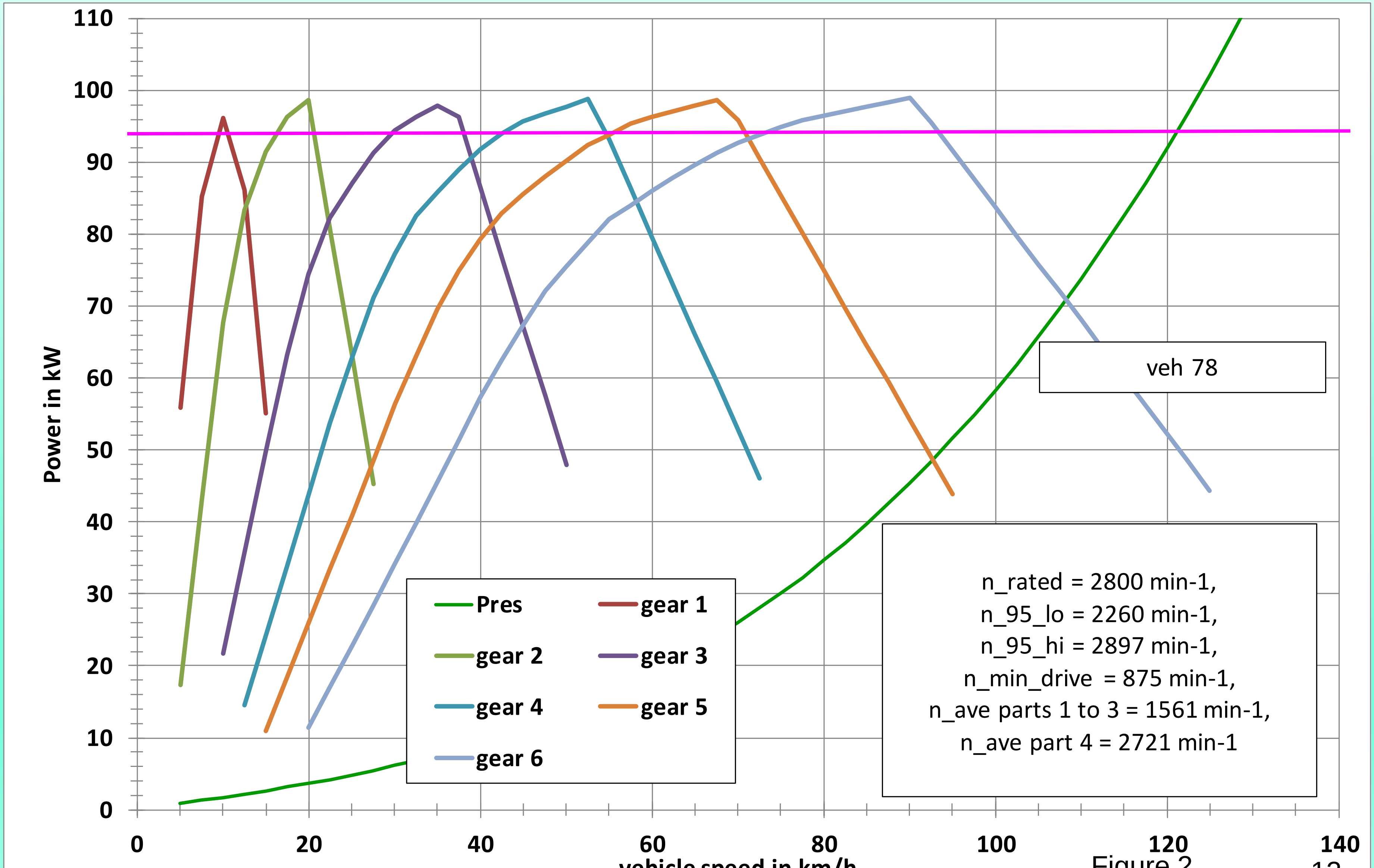

Figure 2

Specifications for n_{max}, para 2 (g)

- Both cases have an extreme high ratio between the engine speed n_{max}(ng_{vmax}) at maximum cycle speed in ng_{vmax} (the gear in which the maximum vehicle speed is reached) and n_{max_95}.
- This ratio is 2,18 for vehicle 108 and 1,80 for vehicle 78. Typical ratios for "normal" vehicles are between 0,65 and 1,25.
- From checks for a series of vehicles can be concluded, that a ratio of 1,7 would be an appropriate borderline.
- Conclusion: A further requirement needs to be added to paragraph 2 (g) or the current requirements need to be replaced in order to solve this problem.

Specifications for n_{max}, para 2 (g)

- The addition of a further requirement is not satifying, because this is then the 3rd time that $n_{max\_95\_low}$ needs to be amended in order to eliminate contradictions with the 2 second rule.
- But one could also replace n_{max_95} by a weighted average of n_{95_low} and $n_{max}(ng_{vmax})$ for such cases, in order to meet the 2 second rule.
- The following examples make clear that it would be more appropriate to replace the current requirements by a better definition of n_{max_95}.
- Another option would be to skip n_{max} requirements completely.

Specifications for n_{max}, para 2 (g)

- Figures 3 and 4 show the available power for all gears and the required power for constant speed driving for two other example vehicles with the same trans-mission design and almost the same wot power curve.
- The rated engine speed for vehicle 2 is at the upper end of the maximum power plateau (3500 min^{-1}) while the rated engine speed for vehicle 3 is at the lower end (2000 min^{-1}).

Available and required power vs speed

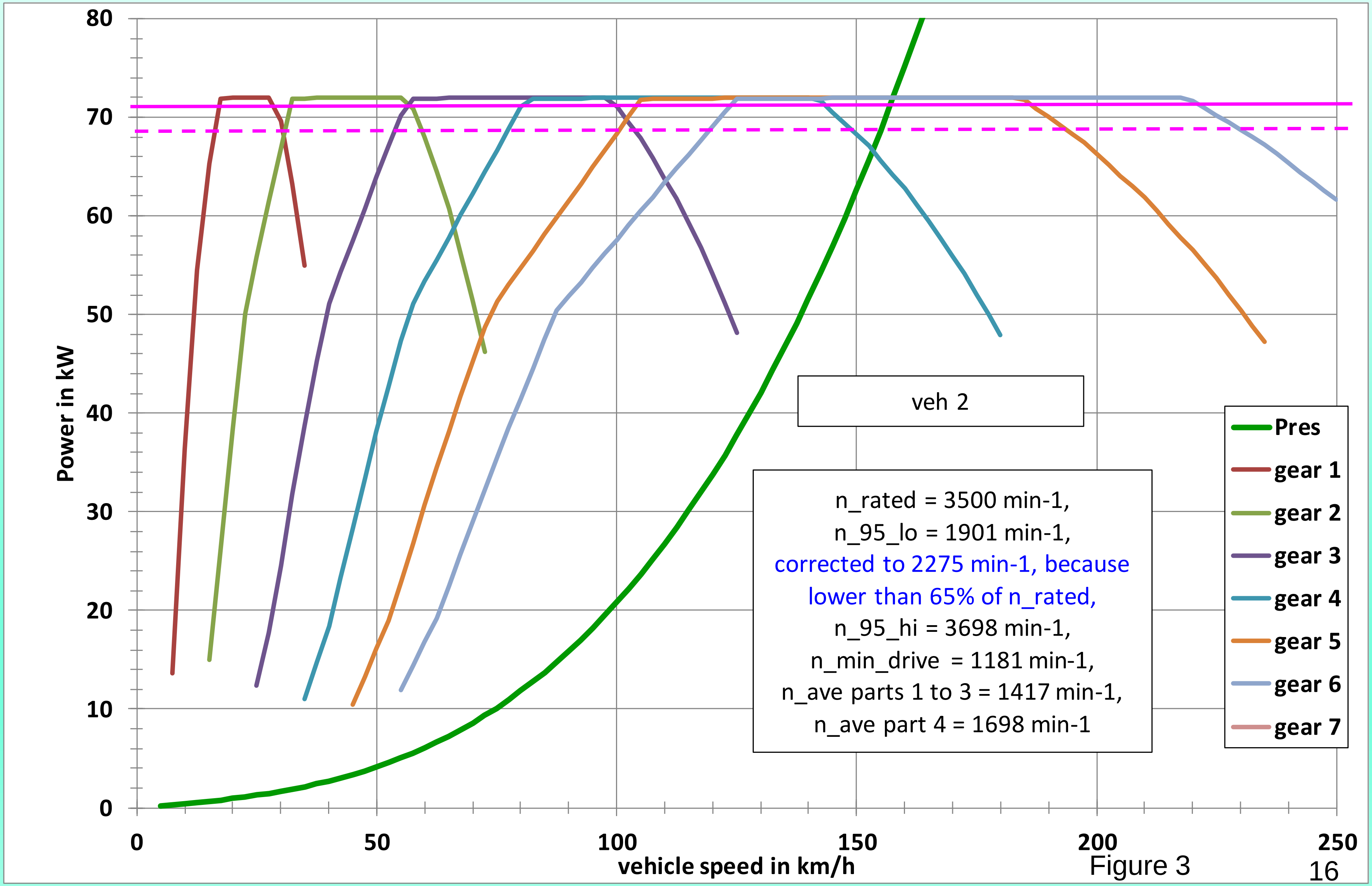

Figure 3

Available and required power vs speed

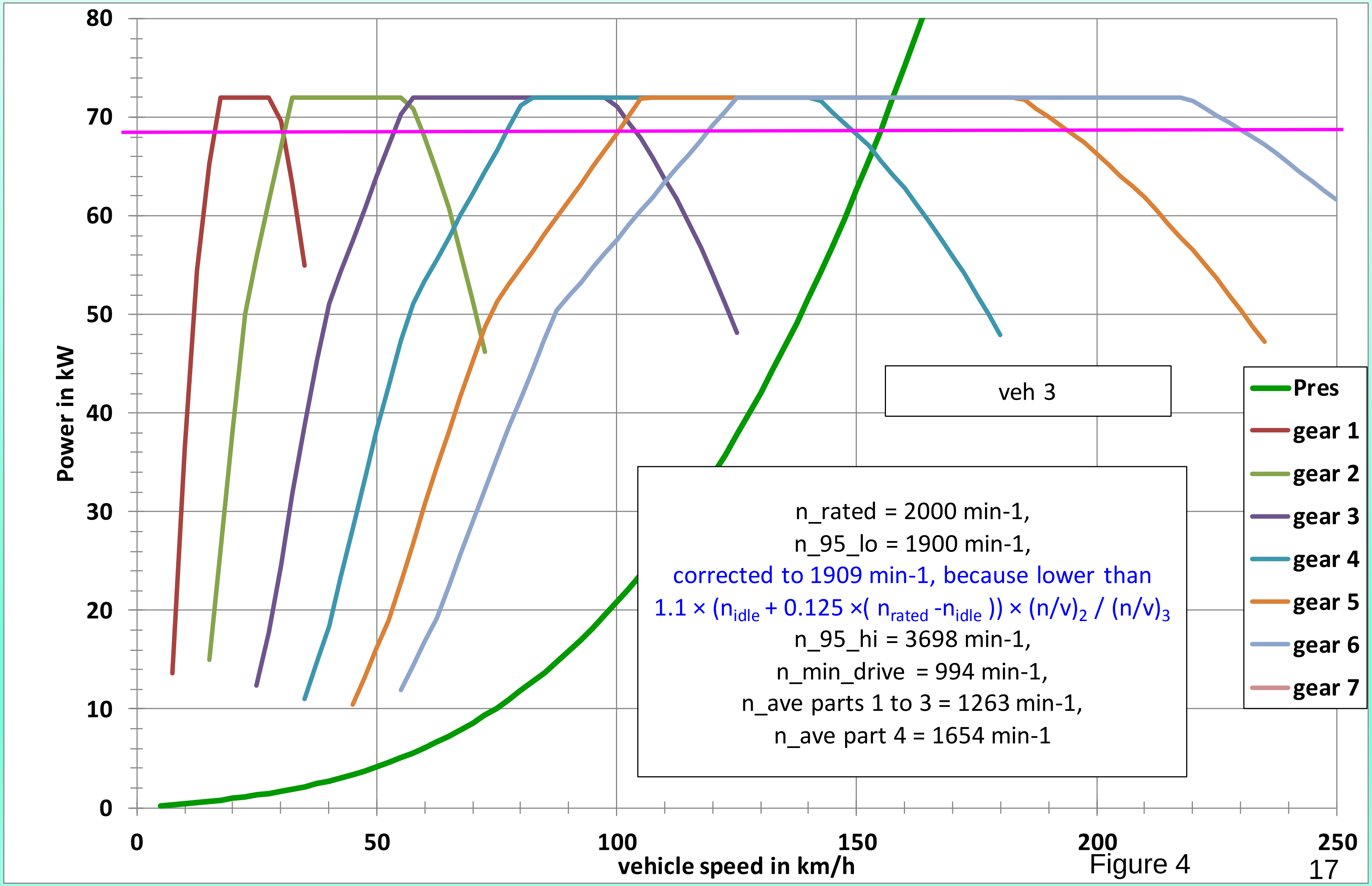

Figure 4

Specifications for n_{max}, para 2 (g)

- It is obvious that there will be no difference between both vehicles with respect to the driving behaviour in practical use. But the key values for the gearshift calculation are significantly different.
- n_{95_low} is 1900 min^{-1} in both cases. But 65% of rated engine speed is 2275 min^{-1} for vehicle 2 and 1300 min^{-1} for vehicle 3. n_{max_95} needs to be corrected according to para 2 (g) to 65% of rated engine speed (2275 min^{-1}) for vehicle 2 and to $1,1 * n_{min\_drive} * (n/v)_2/(n/v)_3$ (1909 min^{-1}) for vehicle 3.
- A common solution for both vehicles can be found, if the ratio between n_{95_high} and n_{95_low} would be used as criterion for an increase of n_{max_95} instead of the existing requirements.

Specs for n_{max}, para 2 (g) and n_{min_drive}

- **In this case the additional criterion in para 2 (g) would be superfluous.**
- **And as for the ratio $n_{max}(ng_{vmax})$ / $n_{max\_95\_low}$ also for this ratio a value of 1,7 would be an appropriate borderline.**
- **But the problems could also be solved by a new definition of n_{max_95} as weighted average of $n_{max\_95\_low}$ and $n_{max\_95\_high}$ or n_{max2} respectively.**
- **Furthermore, n_{min_drive} is significantly different for both vehicles (1181 min^{-1} for vehicle 2 and 994 min^{-1} for vehicle 3).**
- **These differences lead to differences in the average engine speed (without stops) of 11,9% for parts low to high and 2,9% for the extra high speed part between both vehicles.**

Specs for n_{max}, para 2 (g) and n_{min_drive}

- A better solution would be to replace rated engine speed by $n_{max\_95\_high}$ in the equation for the calculation of n_{min_drive}

  $(n_{min\_drive} = n_{idle} + 0{,}125*(\cancel{n_{rated}}\ n_{95\_high} - n_{idle})$

- Of course, the weighting factor of 0,125 would then have to be changed, but both vehicles would get exactly the same n_{min_drive}. This proposal of the chairman was also not yet discussed in the GSTF.

- Another finding from the gearshift calculations for vehicles 2 and 3 was, that the skipping of gears during decelerations required two consecutive seconds with gear 0 because of the low n_{max_95} values.

Specifications for ng_{vmax}, para 2 (i)

- **One of the example vehicles for the RRT have a transmission design, so that the maximum vehicle speed is reached in gear ng-2 (see figure 5).**
- **This is not covered by the current specifications in paragraph 2 (i).**
- **In order to cover also gear ng-2, the text needs to be amended as shown later.**

Prevention of upshifts from acc to dec

- The example vehicle shown in figure 5 has a transmission design which is the opposite of those shown in figures 1 and 2. The two highest gears of this 7speed transmission are designed as “overdrives”, so that the maximum vehicle speed is reached in 5th gear.
- In this case an upshift to a higher gear could occur at the transition from an acceleration or constant speed phase to a deceleration phase, which is not in line with practical use (see annexed Excel file) but not prohibited by the current prescriptions in annex 2.
- This is also the case for 4 of the example vehicles for the RRT.

Available and required power vs speed

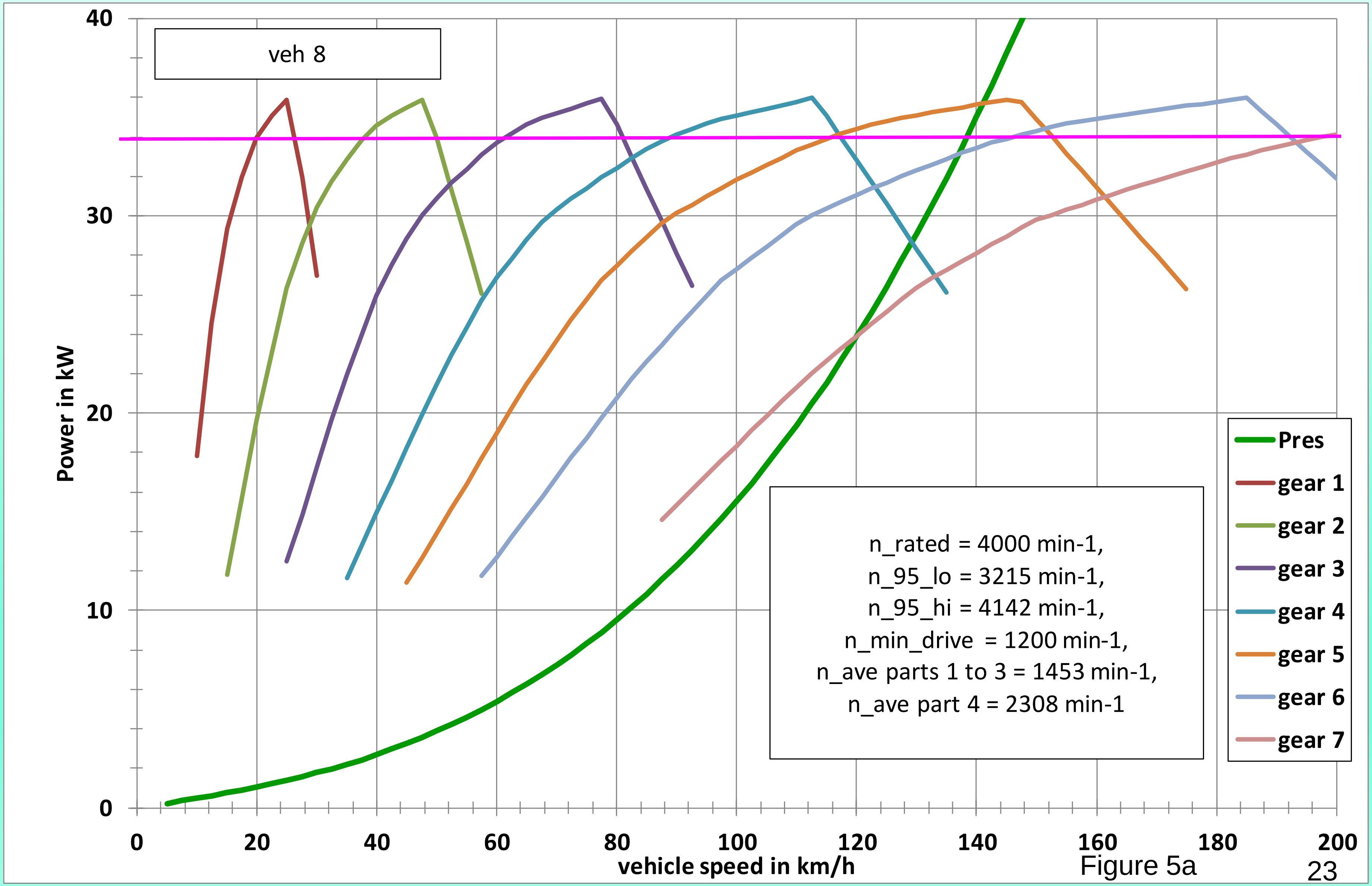

Figure 5a

Available and required power vs speed

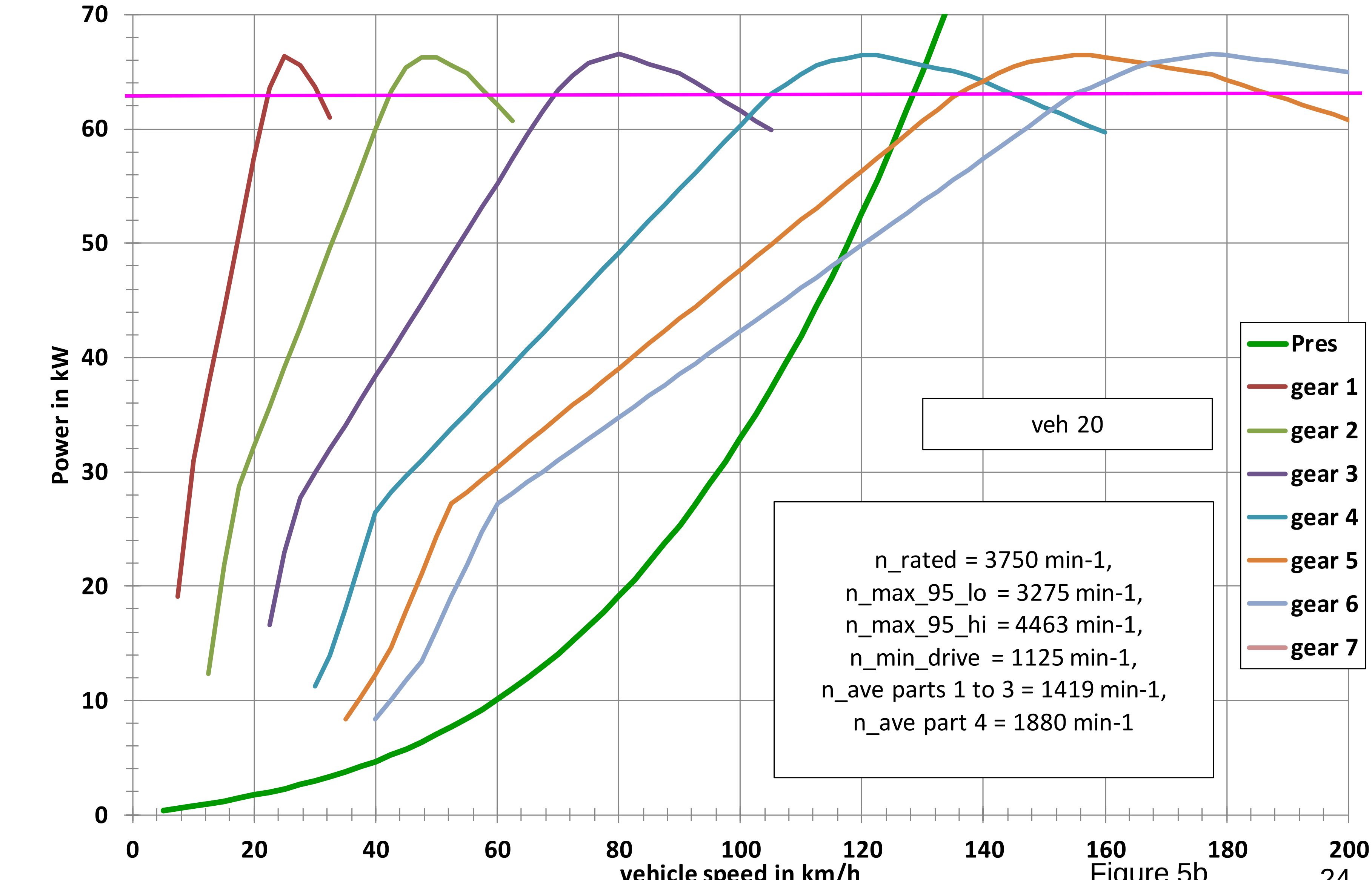

Figure 5b

Proposed modifications for annex 2

- **Based on the findings, reported above, the following paragraphs of annex 2 should be amended:**
  - **Paragraph 2 (g), (h) and (i): modifications related to new specifications for n_{max}.**
  - **Paras 3.3 and 3.5: modifications due to new n_{max}**
  - **Paragraph 4: modify (d), add a new indent (g)**
- **The above listed amendment proposals would avoid errors in the gearshift calculation for vehicles with extreme engine and transmission design but would not affect the results for “normal” vehicles.**
- **Since the chairman’s proposal for a new n_{min_drive} definition would affect all vehicles, more analysis work is necessary and therefore it is not included here.**

Paragraph 2 (g), current version

(g) n_{max}

$n_{max\_95,}$ the minimum engine speed where 95 per cent of rated power is reached, min^{-1};

If n_{max_95} is less than 65 per cent of n_{rated}, n_{max_95} shall be set to 65 per cent of n_{rated};

If 65 per cent of $(n_{rated} \times (n/v)_3 / (n/v)_2) < 1.1 \times (n_{idle} + 0.125 \times (n_{rated} - n_{idle}))$, n_{max_95} shall be set to:

$1.1 \times (n_{idle} + 0.125 \times (n_{rated} - n_{idle})) \times (n/v)_2 / (n/v)_3$

$n_{max}(ng_{vmax}) = (n/v)(ng_{vmax}) \times v_{max,cycle}$

where:

ng_{vmax} is defined in paragraph 2.(i) of this annex;

$v_{max,cycle}$ is the maximum speed of the vehicle speed trace according to Annex 1, km/h;

n_{max} is the maximum of n_{max_95} and $n_{max}(ng_{vmax})$, min^{-1}.

Paragraph 2 (g), amendment proposal

- **Replace the header n_{max} by n_{max1} and n_{max2}, because n_{max} is not used in annex 2.**
- **Replace the requirements for n_{max_95} by:**
  - $n_{max1} = 0{,}667 * n_{95\_low} + 0{,}333 * \max(n_{95\_high}, n_{max2})$
  - $n_{max2} = n_{max}(ng_{vmax}) = (n/v)(ng_{vmax}) \times v_{max,cycle}$
- **The introduction of n_{95_high} has consequences for the engine speed range of the wot power curve (paragraph 2 (h))**

Paragraph 2 (g), proposed version

(g) $\cancel{n_{max}}$ n_{max1}, n_{max2}

$n_{max1} = 0{,}667 * n_{95\_low} + 0{,}333 * \max(n_{95\_high}, n_{max2})$

$n_{\cancel{max\_}95\_low}$, the minimum engine speed where 95 per cent of rated power is reached, min^{-1};

n_{95_high}, the maximum engine speed where 95 per cent of rated power is reached, min^{-1};

~~If n_{max_95} is less than 65 per cent of n_{rated}, n_{max_95} shall be set to 65 per cent of n_{rated};~~

~~If 65 per cent of (n_{rated} × $(n/v)_3$ / $(n/v)_2$) < 1.1 ×(n_{idle} + 0.125 ×(n_{rated} – n_{idle})), n_{max_95} shall be set to:~~

~~1.1 × (n_{idle} + 0.125 ×(n_{rated} – n_{idle})) × $(n/v)_2$ / $(n/v)_3$~~

$n_{max2} = n_{max}(ng_{vmax}) = (n/v)(ng_{vmax}) \times v_{max,cycle}$

where:

ng_{vmax} is defined in paragraph 2.(i) of this annex;

$v_{max,cycle}$ is the maximum speed of the vehicle speed trace according to Annex 1, km/h;

~~n_{max} is the maximum of n_{max_95} and $n_{max}(ng_{vmax})$, min^{-1}.~~

Paragraph 2 (h), amended for n_{95_high}

(h) $P_{wot}(n)$, the full load power curve over the engine speed range.

$(n/v)(ng_{vmax})$ is the ratio obtained by dividing the engine speed n by the vehicle speed v for the gear ng_{vmax}, $min^{-1}/(km/h)$;

The power curve shall consist of a sufficient number of data sets (n, P_{wot}) so that the calculation of interim points between consecutive data sets can be performed by linear interpolation. Deviation of the linear interpolation from the full load power curve according to Regulation No. 85 shall not exceed 2 per cent. The first data set shall be at n_{min_drive} of $n_{gear} > 2$ (see (k) below) or lower. The last data set shall be at $\cancel{n_{rated}}$ n_{95_high} or n_{max2}, $\cancel{\text{or } (n/v)(ng_{vmax}) \times v_{max}}$, whichever is greater. Data sets need not be spaced equally. The full load power at engine speeds not covered by Regulation No. 85 shall be determined according to the method described in Regulation No. 85;

Specifications for ng_{vmax}, para 2 (i)

- **The current text reads as follows:**

(i) ng_{vmax}

ng_{vmax}, the gear in which the maximum vehicle speed is reached and shall be determined as follows:

If $v_{max}(ng) \geq v_{max}(ng\text{-}1)$, then,

$ng_{vmax} = ng$ and $v_{max} = v_{max}(ng)$,

otherwise, $ng_{vmax} = ng -1$ and $v_{max} = v_{max}(ng\text{-}1)$

- **In order to cover also gear ng-2, the text needs to be amended as follows:**

Specifications for ng_{vmax}, para 2 (i)

(i) ng_{vmax}, v_{max}

ng_{vmax}, the gear in which the maximum vehicle speed is reached and shall be determined as follows:

If $v_{max}(ng) \geq v_{max}(ng-1)$ and $v_{max}(ng-1) >= v_{max}(ng-2)$, then,

$ng_{vmax} = ng$ and $v_{max} = v_{max}(ng)$,

if $v_{max}(ng) < v_{max}(ng-1)$ and $v_{max}(ng-1) >= v_{max}(ng-2)$, then

$ng_{vmax} = ng-1$ and $v_{max} = v_{max}(ng-1)$,

otherwise, $ng_{vmax} = ng-2$ and $v_{max} = v_{max}(ng-2)$

where:

$v_{max}(ng)$ is the vehicle speed at which the required road load power equals the available power P_{wot} in gear ng (see Figure A2/1a).

$v_{max}(ng-1)$ is the vehicle speed at which the required road load power equals the available power P_{wot} in the next lower gear (see Figure A2/1b).

$v_{max}(ng-2)$ is the vehicle speed at which the required road load power equals the available power P_{wot} in gear ng-2.

Vehicle speed values rounded to one place of decimal shall be used for the determination of v_{max} and ng_{vmax}.

Para 3.3, amended for n_{max1} and n_{max2}

- **n_{max_95} and $n_{max}(ng_{vmax})$ can be replaced by n_{max1} and n_{max2}**

3.3. Selection of possible gears with respect to engine speed

The following gears may be selected for driving the speed trace at v_j:

(a) All gears $i < ng_{vmax}$ where $n_{min\_drive} \leq n_{i,j} \leq n_{max1}$;

(b) All gears $i \geq ng_{vmax}$ where $n_{min\_drive} \leq n_{i,j} \leq n_{max2}$;

Para 3.5, amended for n_{max1}

- **Since the new proposal for n_{max1} could exceed n_{rated}, the following modifications need to be made in paragraph 3.5:**

3.5. Determination of possible gears to be used

The possible gears to be used shall be determined by the following conditions:

(a) The conditions of paragraph 3.3. of this annex are fulfilled, and

(b) If $n_{i,j} \geq$ minimum engine speed of the P_{wot} curve (see paragraph 2.(h) of this annex), $P_{available\_i,j} \geq P_{required\_,j}$.

If in (b) $P_{available,i,j} \geq P_{required,j}$ can only be fulfilled in gear ng-1 when paragraph 3.3.(a) of this annex cannot be fulfilled because the corresponding engine speed exceeds n_{max1} and n_{max1} is lower than n_{rated}, this shall be accepted as long as the engine speed does not exceed n_{rated}.

If in (b) $P_{available,i,j} \geq P_{required,j}$ can only be fulfilled in a gear in which n_{rated} or n_{max1}, whichever is higher is exceeded, the next higher gear shall be used.

Paragraph 4 (d), current version

(d) During a deceleration phase, gears with $n_{gear} > 2$ shall be used as long as the engine speed does not drop below n_{min_drive}.

If the duration of a gear sequence is only 1 second, it shall be replaced by gear 0 and the clutch shall be disengaged.

If the duration of a gear sequence is 2 seconds, it shall be replaced by gear 0 for the 1st second and for the 2nd second with the gear that follows after the 2 second period. The clutch shall be disengaged for the 1st second.

Example: A gear sequence 5, 4, 4, 2 shall be replaced by 5, 0, 2, 2.

This requirement shall only be applied if the gear that follows after the 2 second period is > 0.

Paragraph 4 (d), amendment proposal

- **The requirements in paragraph 4 (d) need to be amended for those cases, where the use of the following lower gear would be prohibited by the n_{max1} requirements.**
- **In these cases it is proposed to allow a 2nd second with gear 0 and the clutch disengaged.**
- **With the new n_{max1} requirements these cases are quite unlikely, but the prescriptions should not leave any gaps.**

Paragraph 4 (d), amendment proposal

(d) During a deceleration phase, gears with $n_{gear} > 2$ shall be used as long as the engine speed does not drop below n_{min_drive}.

If the duration of a gear sequence is only 1 second, it shall be replaced by gear 0 and the clutch shall be disengaged.

If the duration of a gear sequence is 2 seconds, it shall be replaced by gear 0 for the 1st second and the clutch shall be disengaged for the 1st second.

For the 2nd second the gear shall be replaced with the gear that follows after the 2 second period, if the engine speed in that gear does not exceed n_{max1}. Otherwise the gear shall be set to 0 and the clutch shall be disengaged.

Example: A gear sequence 5, 4, 4, 2 shall be replaced by 5, 0, 2, 2.

This requirement shall only be applied if the gear that follows after the 2 second period is > 0.

Paragraph 4 (g), amendment proposal

- **In order to avoid normally unlikely upshifts during the transition from an acceleration or a constant speed phase to a deceleration phase, the following new indent (g) should be added to paragraph 4.**

(g) No upshift to a higher gear at the transition from an acceleration or constant speed phase to a deceleration phase.

Example: If $v_i <= v_{i+1}$ and $v_{i+2} < v_{i+1}$ and $gear_i = 4$ and $gear_{i+1} = 5$ and $gear_{i+2} = 5$, then $gear_{i+1}$ and $gear_{i+2}$ shall be set to 4. For all following cycle trace points with gear = 5 within the deceleration phase the gear shall also be set to 4.

End

Thank you for your attention!