Working Paper No. **HDH-15-07e**
(15th HDH meeting, 24 to 25 October 2013)

Development of WHVC weighting factors

Summary of work performed in

HDH research program – task 5
10/2011 – 06/2012

Overview

- This task was performed in first project phase (i.e. HDH research program) in 2012
- Not connected to current work program
- Basic methodology was finished in 06/2012
- Final weighting factors for all mission specific cycles calculated in beginning of 2013 after availability of all European CO2 test cycles

Background information

- HDH-IG decided to use WHVC cycle as starting point for research on the HILS testing procedure
- Given research task:

  „In order to take specific vehicle operation into account, modifications to the WHVC with respect to using subsets of the cycle (urban, rural, motorway) in combination with appropriate weighting or scaling factors should be investigated.
  WHVC weighting/scaling factors to represent real world vehicle operation should be developed."

Background information

- Weighting factors for different vehicle categories need several definitions and data:
  - Definition of „vehicle classification“ (bus, coach, delivery, long haul,..)
  - Representative „real world“ driving cycles for each class to compare with the WHVC
- Basis of the work were vehicle classes and driving cycles from the European CO2 test procedure for HDV
- Methodology can be used universally to calculate weighting factors for the WHVC with other test cycles

Background information

- 17 classes of heavy goods vehicles >7.5t GVW

Heavy Goods Vehicles

	Identification of vehicle class					Segmentation (vehicle configuration and cycle allocation)					Norm body allocation		
Axles	Axle configuration	Chassis configuration	Maximum GVW [t]	<-- Vehicle class		Long haul	Regional delivery	Urban delivery	Municipal utility	Construction	Standard body	Standard trailer	Standard semitrailer
2	4x2	Rigid	>3.5 - 7.5	0			R	R			B0		
2	4x2	Rigid or Tractor	7.5 - 10	1			R	R			B1		
		Rigid or Tractor	>10 - 12	2		R	R	R			B2		
		Rigid or Tractor	>12 - 16	3			R	R			B3		
		Rigid	>16	4		R+T	R		R		B4	T1	
		Tractor	>16	5		T+S	T+S						S1
	4x4	Rigid	7.5 - 16	6					R	R	B1		
		Rigid	>16	7						R	B5		
		Tractor	>16	8						T+S			W1?
3	6x2/2-4	Rigid	all weights	9		R+T	R		R		B6	T2	
		Tractor	all weights	10		T+S	T+S						S2
	6x4	Rigid	all weights	11						R	B7		
		Tractor	all weights	12						R			S3
	6x6	Rigid	all weights	13						R	W7		
		Tractor	all weights	14						R	W7		
4	8x2	Rigid	all weights	15			R				B8		
	8x4	Rigid	all weights	16						R	B9		
	8x6 & 8x8	Rigid	all weights	17						R	W9		

Background information

- 6 bus and coach classes

Bus + Coach	Identification of vehicle class						Segmentation and cycle allocation				
	Axles	Axle configuration	Chassis configuration	Characteristics	Maximum GVW [t]	<-- Vehice class	Heavy Urban	Urban	Suburban	Interurban	Coach
	2	4x2	City	Class I + low floor or low entry, no luggage compartment	<18	B 1	HU	UR	SU		
			Interurban	Class II + luggage compartment and/or floor height ≤0.9m	<18	B2				IU	
			Coach	Class III + floor height ≥0.9m and/or double decker	<18	B3					CO
	3	6x2	City	Class I + Low floor or low entry, no luggage compartment	>18	B4	HU	UR	SU		
			Interurban	luggage compartment and/or floor height ≤0.9m	>18	B5				IU	
			Coach	floor height ≥0.9m and/or double decker	>18	B6					CO

HGV: 17 classes 5 cycles
Bus & Coach: 6 classes 3 cycle (sets)

Total 23 HDV classes 8 cycles

Background information

- Influence of vehicle class via vehicle specific data on resulting engine load cycle and thus resulting weighting factors very small
- Only cycle specific influences were considered (as decided in 9th HDH meeting)
- **Calculation of weighting factors for 8 mission specific test cycles done**

- Calculation with generic standard vehicle for each class
- Sensitivity analysis showed that variation of vehicle mass, cd*A and RRC of +/-10% resulted only in variation of the weighting factors of <3%

Methodology

- Simulate kinematic parameters for the WHVC-sub-cycles (Urban, Rural, Motorway)
- Simulate kinematic parameters for “representative” HDV CO2 test cycles
- Calculate the weighting factors (WF) by following equations:
  - 1) WF_WHVC-Urban + WF_WHVC-Rural + WF_WHVC-Motorway = 1.0
  - 2) Deviation of kinematic parameters between weighted WHVC and representative cycle is minimum

$$\sum_{n=Urban,Rural}^{Motorway} \left(WF_{WHVC-n} \times \sum_{i=\text{Kin.Param 1}}^{\text{Kin.Param j}} WF_{Ki} \times \left| \left(\frac{KPi_{RS} - KPi_{WHVC-n}}{KPi_{RS}} \right) \right| \right) = KP_{Tot} = Minimum$$

WHVC-Weighting Factor

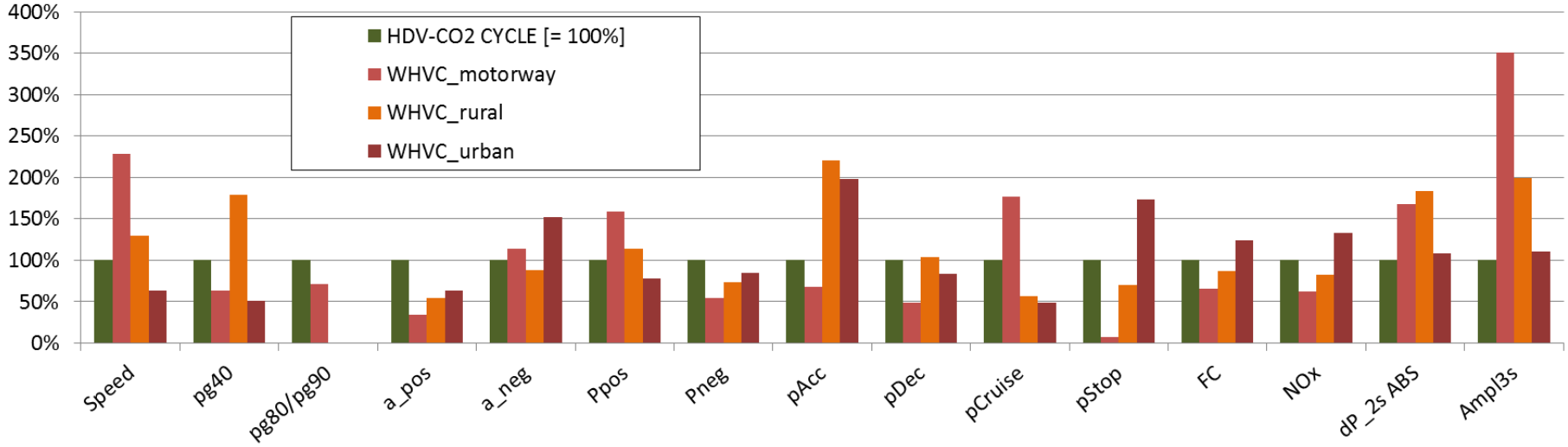
Kinematic parameter i in WHVC-Sub-cycle

Kinematic parameter i in representative cycle

Weighting of the kinematic parameter i

Methodology

Example data for interurban bus cycle



WF_{Ki} :

Speed	pg40	pg80	a_pos	a_neg	Ppos	Pneg	pAcc	pDec	pCruise	pStop	FC	NOx	dP_2s ABS	Ampl3s	Total
0.075	0.100	0.100	0.075	0.075	0.075	0.075	0.075	0.000	0.075	0.075	0.100	0.000	0.050	0.050	1.0000

Variation of WHVC weighting factors:

WF_WHVC_Motorway	0.33	0.20	0.25	0.19
WF_WHVC_Rural	0.33	0.30	0.25	0.36
WF_WHVC_Urban	0.34	0.50	0.50	0.45
KP_{tot}	**0.3498**	**0.3291**	**0.3289**	**0.3248**

towards minimum

Minimum of KP_{tot}

Results

- Final results for WHVC weighting factors for all 8 European mission specific driving cycles

driving cycle	WF_motorway	WF_rural	WF_urban
long haul	90%	0%	11%
regional	54%	30%	17%
urban	4%	27%	69%
municipial utility	2%	0%	98%
construction	6%	32%	62%
citybus	0%	0%	100%
interurban bus	19%	36%	45%
coach	78%	22%	0%

Detailed information can be found in a report document published within the next weeks.

Conclusion

- WHVC weighting factors developed which take specific vehicle operation into account (theoretical method)
- Nevertheless usage for HDH is not recommended
  - No comparability to conventional HDV
  - Against fundamental idea of WHTC development
  - Unfair higher weighting of chronologically early test phases (first and second phase of WHTC/WHVC) with lower temperatures of exh. aftertreatment system
  - Would require a whole new approach for (engine) test cycles as basis