

World Harmonized Duty Cycle (WHDC) Test Programme on WHDC Option No. 5

Interims Report

**25th WHDC Meeting
15 - 17 October 2008
Beijing**

PM variables to be investigated - I

- 47 mm vs. 70 mm filter size for
 - TX40 EMFAB (PTFE coated glass fibre) and
 - TEFLO Filter using bonded ring (PTFE membrane)
=> *70 mm TEFLO filter with ring not available*

- Correlation
 - Partial and full flow systems for PM.
 - Full flow sampling and raw gas sampling for gaseous components.
 - CPC according to PMP at full flow and partial flow system for at least 7 cycles.

- Sampling probes
 - CVS PM probe with 8 mm internal diameter to be used (min. 12 mm requested by current EC regulation).
 - Partial flow PM probe min. 4mm according to WHDC GTR

PM variables to be investigated - II

Influence of sampling system residence time and filter face velocity

- Requested residence time for dilution systems 1 to 5 seconds from inlet of tunnel until filter face for full flow and partial flow system.
- For CVS at least 0.5 seconds residence time for secondary dilution.
- On CVS (FF) two different CVS flow with one Filter Face Velocity.
- CVS flow constant, FFV variation via Gprobe.
- On partial flow system Gtot variation => FFV / Residence time variation.

Other sampling conditions

- Sample line length for partial flow system as short as possible.
- Dilution ratio minimum at full load between 5:1 – 7:1 with at least 2:1 in pri. tunnel
- Variation in partial flow system via Gdil with Gtot = const. (FFV / FFT = const.)
to archive 5:1 and 10:1 overall dilution ration in the partial flow system

Test engines – Test cycles

- Engine No. 1

- IVECO F4AE with SCRT System, Euro V / EEV
- $V_H = 5883 \text{ cm}^3$, $P = 205 \text{ kW @ } 2500 \text{ 1/min}$

- Engine No. 2

- Mercedes Benz OM501 with SCR System, Euro V / EEV
- $V_H = 11946 \text{ cm}^3$, $P = 350 \text{ kW @ } 1800 \text{ 1/min}$

- WHTC, every first cycle per day cold, all other hot and WHSC

- Each test to be run 7 times (at least)
- Pre-conditioning for the cold cycle to be performed as last cycle per day
- Soak Time to be considered: 10 min

Parameter set-up – Engine I

Full flow / CVS (FF)

variation [-]	filter [mm]	venturi [-]	Gtot [g/s]	FFV [cm/s]	dilution			r [%]	CVS Distance: mixer - probe [cm]	SPC Distance: probe inlet - filter [cm]	Residence time [s]		CVS flow [kg/h]		
					prim.	sec.	total				CVS	SPC		total	
1	47	1+2	0,9	63	3:1	2:1	6:1	0,042	360	see sheet "Residence time SPC"	0,39	2,02	2,41	~ 4000	
	70			26								2,29	2,68		
2	47		1,4	98								0,065	1,95		2,34
	3		47	0,9											
4		1,4			98	0,072	1,30	1,53							
	Limitation: max. 100 cm/s			Limitation: min. 2:1							Limitation: 5:1 - 7:1			Limitation: mind. 0,5 s	Requested: 1 - 5 s

Partial flow (PF)

variation [-]	filter [mm]	Gtot [g/s]	dilution q [-]	FFV [cm/s]	r [%]	SPC Distance: probe inlet - filter [cm]	SPC Residence time [s]
70	26	1,93					
2	47	1,4	98	0,093	1,06		
	3	47			0,9	63	0,03
4			1,4	98			
	Limitation by SPC: 0,8 - 2,0 g/s				Limitation: max. 100 cm/s	Requested: 1 - 5 s	
47	0,8	56	1,06				
	2,0	139					
70	0,8	23					
	2,0	57					

Parameter set-up – Engine II

Full flow / CVS (FF)

variation [-]	filter [mm]	venturi [-]	Gtot [g/s]	FFV [cm/s]	dilution			r [%]	CVS	SPC	CVS	SPC	total	CVS flow [kg/h]			
					prim.	sec.	total [-]		Distance: mixer - probe [cm]	Distance: probe inlet - filter [cm]	Residence time [s]						
1	47	2+3	0,9	63	3,4:1	1,8:1	~ 6:1	0,021	360	see sheet "Residence time SPC"	0,16	2,02	2,18	~ 8400			
	70			26								2,29	2,45				
2	47		1,4	98	4:1	1,5:1						~ 6:1	0,023		0,14	1,95	2,11
3	47		1+2+3	0,9												63	~ 6:1
4		1,4		98	0,035	0,14	1,30	1,44									
				Limitation: max. 100 cm/s			Limitation: min. 2:1	Limitation: 5:1 - 7:1				Limitation: mind. 0,5 s	Requested: 1 - 5 s				

Partial flow (PF)

variation [-]	filter [mm]	Gtot [g/s]	dilution		r [%]	SPC	SPC		
			q [-]	FFV [cm/s]		Distance: probe inlet - filter [cm]	Residence time [s]		
1	47	0,9	5	63	0,034	see sheet "Residence time SPC"	1,65		
	70			26			1,93		
2	47			1,4			98	0,052	1,06
3	47			0,9			10	63	0,017
4		1,4	98		0,026	1,65			
		Limitation by SPC: 0,8 - 2,0 g/s		Limitation: max. 100 cm/s		Requested: 1 - 5 s			
	47	0,8		56					
		2,0		139					
	70	0,8		23					
		2,0		57					

Results – Engine I

1. Gaseous Components

1.1 Overview

1.2 NO_x Comparison FF / PF

1.3 CO₂ Comparison FF / PF

2. Particulate Matter

2.1 Overview

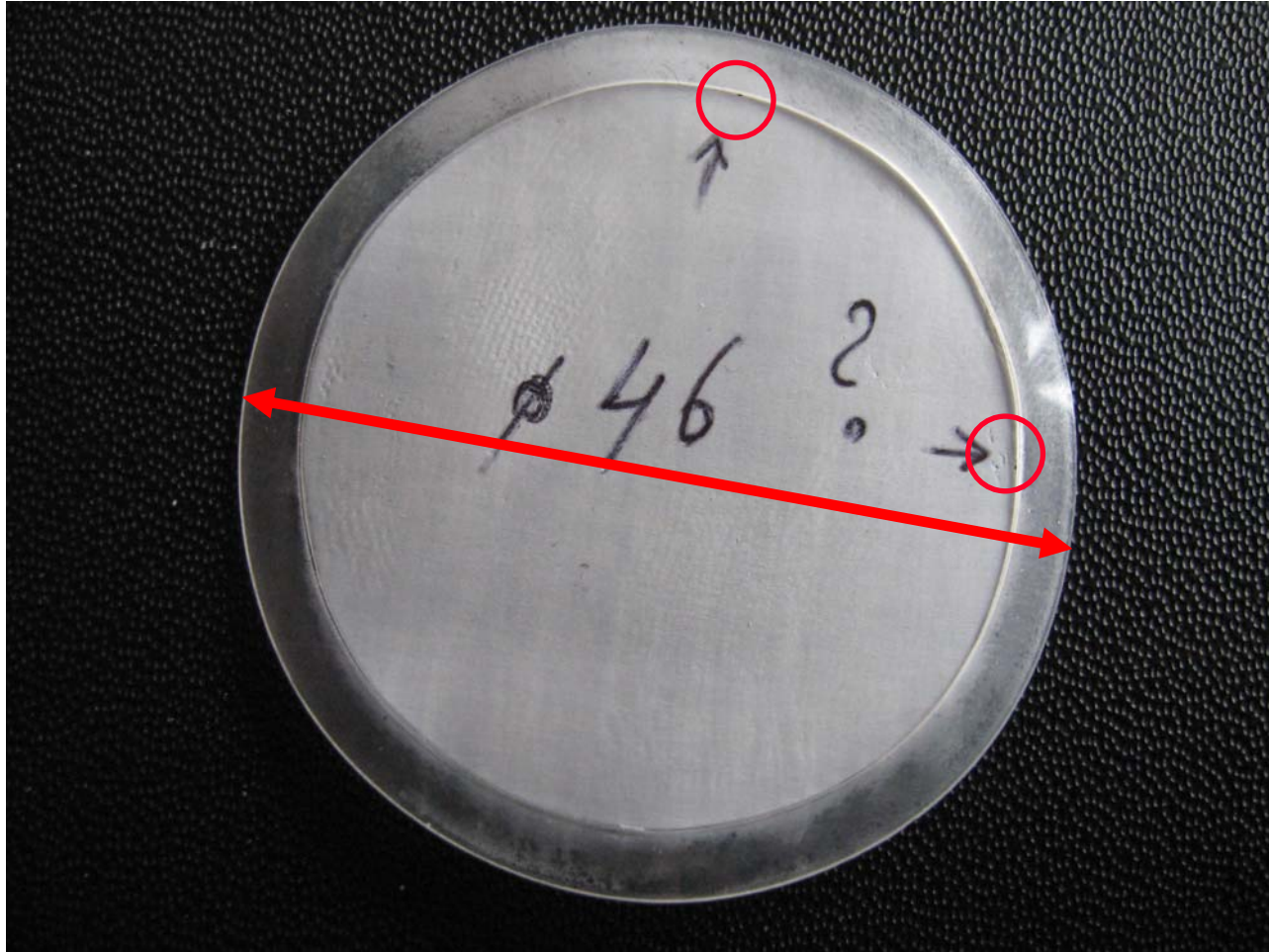
2.2 Parameter Variations – Preliminary results

=> => => Excel File

TX Filter vs. Teflo Filter

- **Both filter materials came from same supplier.**
- **Teflo filter is hard to handle.**
 - => e.g. sticks to filter holder form PF system**
- **Teflo weighing results on engine I not reliable.**
 - => less filter weight / much higher filter weight (electrostatic charge?)**
- **Teflo filter showed further remarkable details such as:**

Teflo Filter - I



Several filter showed small perforation at the edge between filter and ring as delivered.

Teflo Filter - II

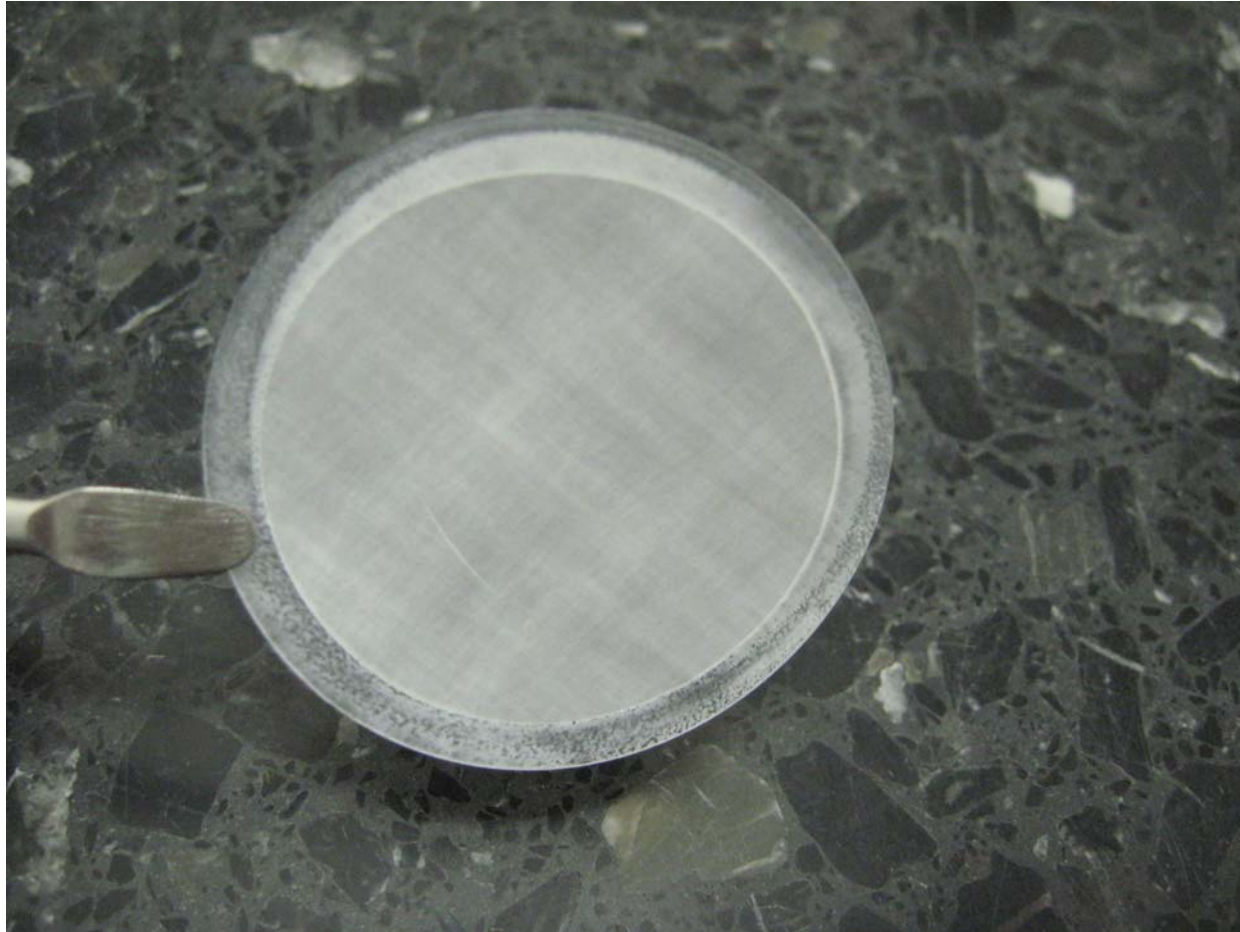


Due to its smaller size the Teflo filter is not properly aligned in filter holder.

Therefore it is possible that some area of the bonded ring is situated in the flow while other area of the filter is clamped by the filter holder.

Mechanical movement of filter holder plate cause movement of the filter in open holder too (abrasion of sampled material?).

Teflo Filter - III



PM loading on bonded ring.

Teflo Filter – IV, Discharging essential



§1065.190 PM-stabilization and weighing environments for gravimetric analysis.

- (6) We recommend that you neutralize PM sample media (e.g. filter) to within ± 2.0 V of neutral. Measure static voltages as follows:
- (i) Measure static voltage of PM sample media (e.g. filter) according to the electrostatic voltmeter manufacturer's instructions.
 - (ii) Measure static voltage of PM sample media (e.g. filter) while the media is at least 15 cm away from any grounded surfaces to avoid mirror image charge interference.

CPC / Number counting

Hose pump – hose material



The material of the hose pump hose was prone to excessive wear and clogging during the testing on Engine I.

Possible reason:

CPC operation on Engine with SCR (SCRT) system;

NH₃ slip or „attack“ by other products formed by the SCR system respect. the reagent used (Isocyanursäure, Biuret, etc.).



Ongoing Activities

- Engine II running at the moment
- CPC / Number count measurements included
- Evaluation in progress (parameter variations)

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