Experimental program with retrofit open particulate filters for diesel trucks

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Contents

1. Introduction

- In The Netherlands from 2006 onwards installation of HD retrofit soot filters (semi-open and closed) have been subsidized by the Dutch government

- HD retrofit soot filters

Type/Name	Req.eff. [%]	Subsidy [€]		Number installed
		150-225 kW 2006 / 2009	> 225 kW 2006 / 2009	2006 - 2009
Open / PM-cat	> 50%	4250 / 0	6250 / 0	15000
Closed / DPF	> 90%	7000 / 5500	9000 / 0	8000

2. Objectives

- Determination of the efficiency of used retrofit open particulate filters (PM-cat) for trucks in **real world** conditions

- PM-cat efficiency in urban areas?
- Effect of 1 hour motorway use on efficiency in urban areas?
- Aging effects?
- Soot loading versus efficiency?
- Regeneration behaviour

3. Experimental set up

Part 1:

- 1 HD-engine 355 kW Euro III on **engine dynamometer** (TNO-The Netherlands)
- 6 used PM-cats (open)

Part 2:

- 3 different Euro III delivery trucks on **chassis dynamometer** (VTT-Finland)
- 7 used PM-cats (open)

3. Experimental set up engine dyno

- 12 litre Euro III engine, 355 kW
- Full flow dilution tunnel + CVS
- AVL 439 smoke meter
- EN590 fuel (S<10 ppm)

- 6 used PM-cats of 1 type (pre oxicat + filter element)
- 65 emission tests engine out
- 130 emission tests PM-cat 1 - 6

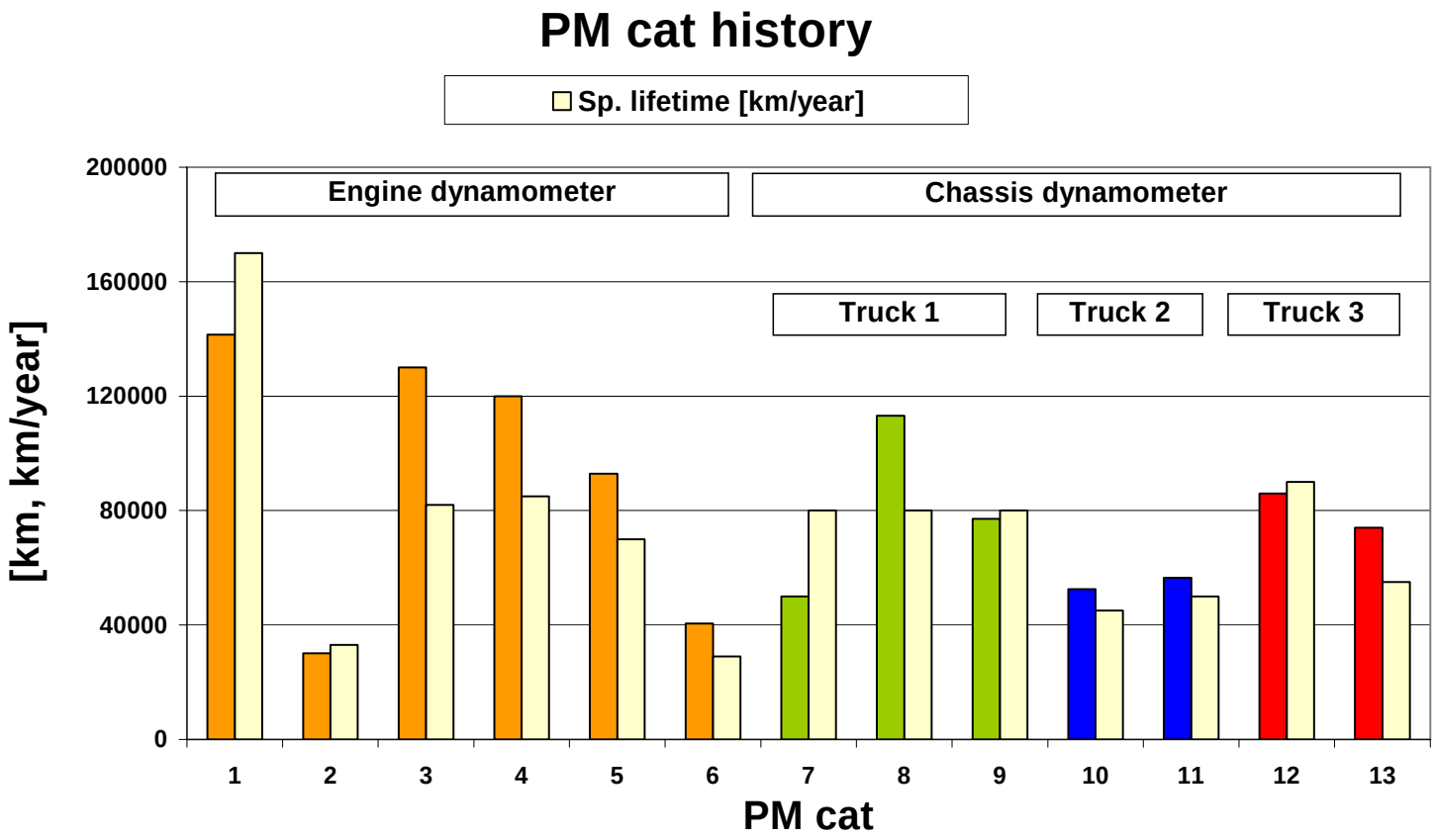
3. Experimental set up chassis dyno

- 3 different delivery trucks Euro III
- Chassis dynamometer
- Full flow dilution tunnel + CVS
- EN590 fuel (S<10 ppm)

- 7 used PM-cats of 4 types
- 70 emission tests engine out
- 145 emission tests with PM-cat

Number of emission tests		
	Engine out	PM-cat
Truck 1	21	61
Truck 2	25	42
Truck 3	24	42

3. History and use 13 PM-cats



- **10 PM-cats 80.000 – 140.000 km and 3 PM-cats 30.000 – 50.000 km**
- **Most PM-cats have run 1 – 1,5 year**

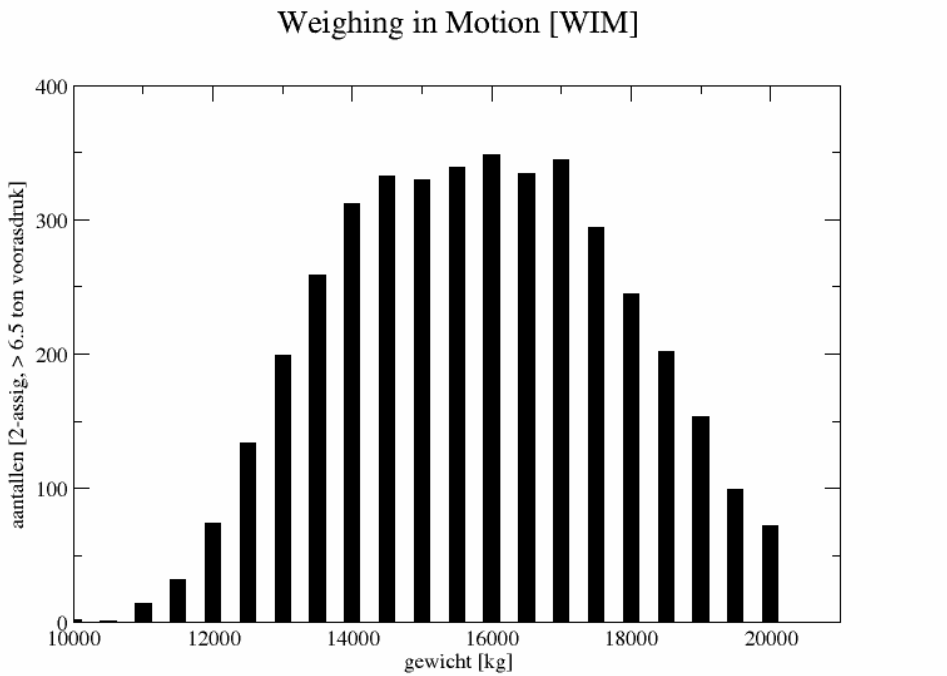
4. Test cycles

Engine dynamometer	**Chassis dynamometer**
WHTC urban part cold 900 s	City Cycle 11,5 tonne 1234 s
WHTC urban part hot 900 s	City Cycle 18,5 tonne 1234 s
ETC (Type approval PM-cat) 1800 s	Motorway 11,5 tonne 1272 s
Motorway (85 km/h)	Motorway 18,5 tonne 1272 s

Do the test cycles cover real world conditions?

4. Motorway total vehicle weight distribution truck

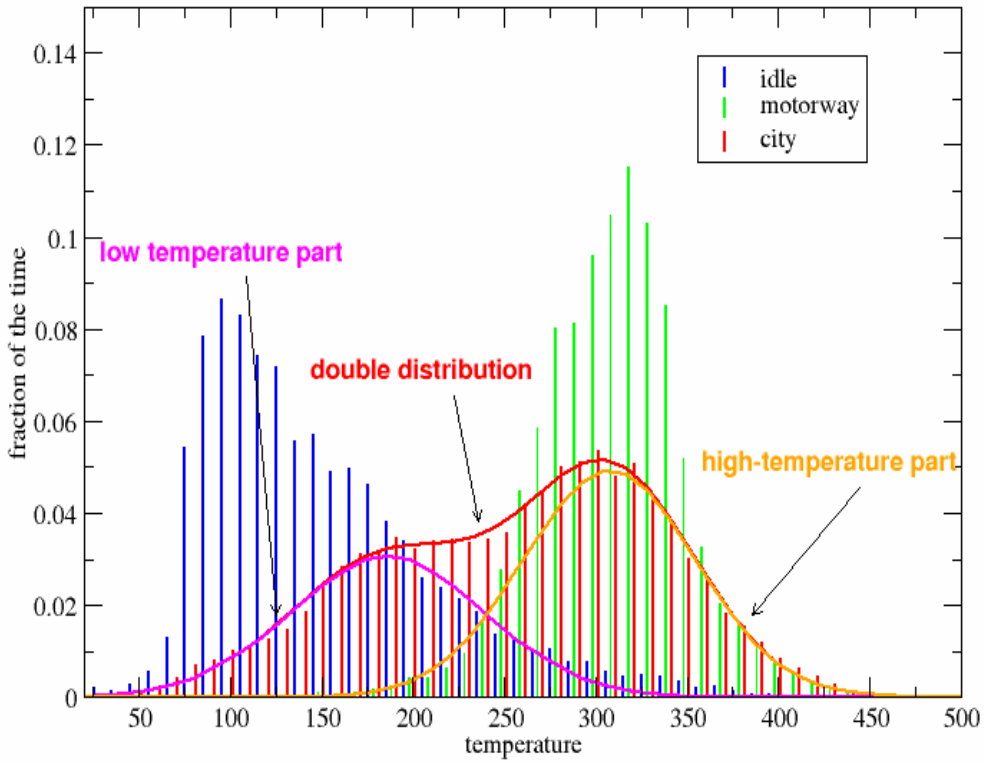
(real world)



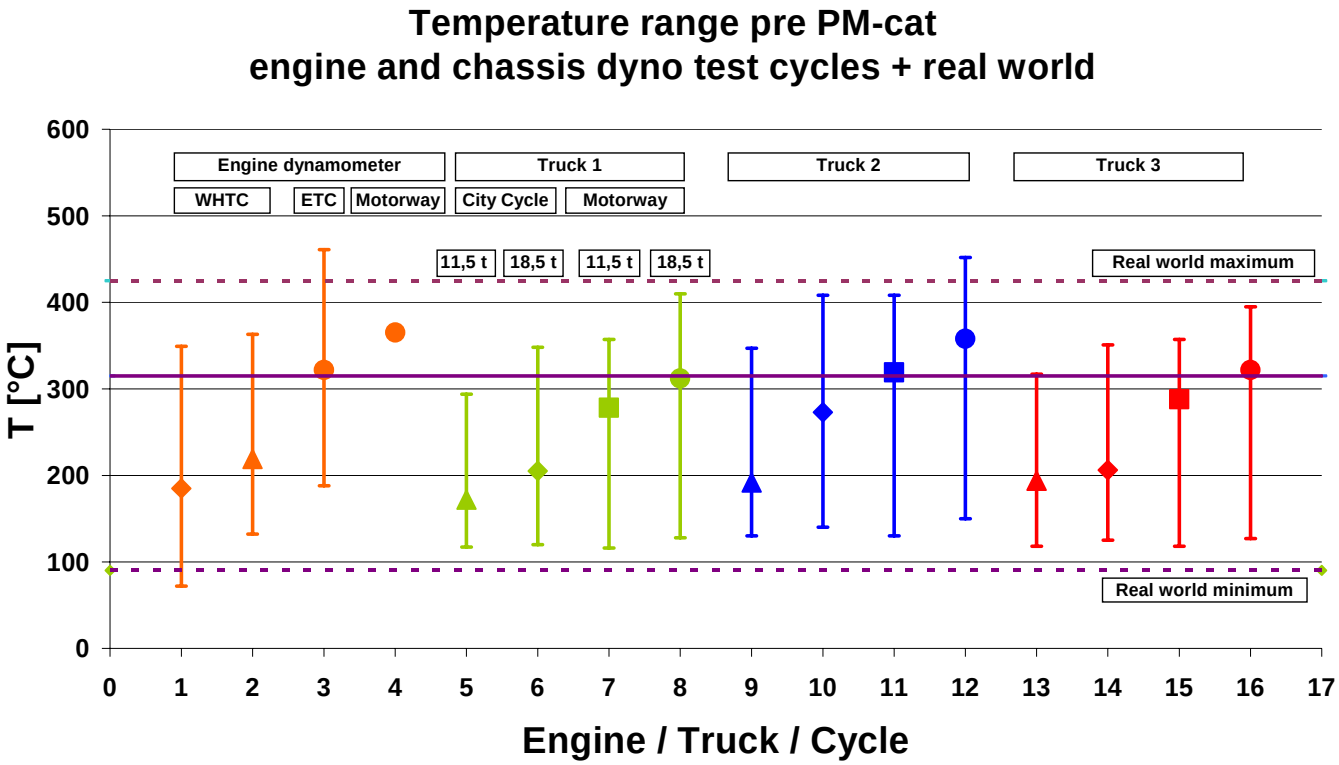
- **Minimum truck weight 11 tonne, Maximum truck weight 20 tonne**
- **(source: highway automatic truck weighing system, 4000 trucks)**

4. Delivery truck real world temperature distribution

- Data: 1 truck, 300 days, 24h per day
- User profile: Start 90% vehicle load, motorway. Generally re-load at mid day. Empty in 2-3 stops (half day)



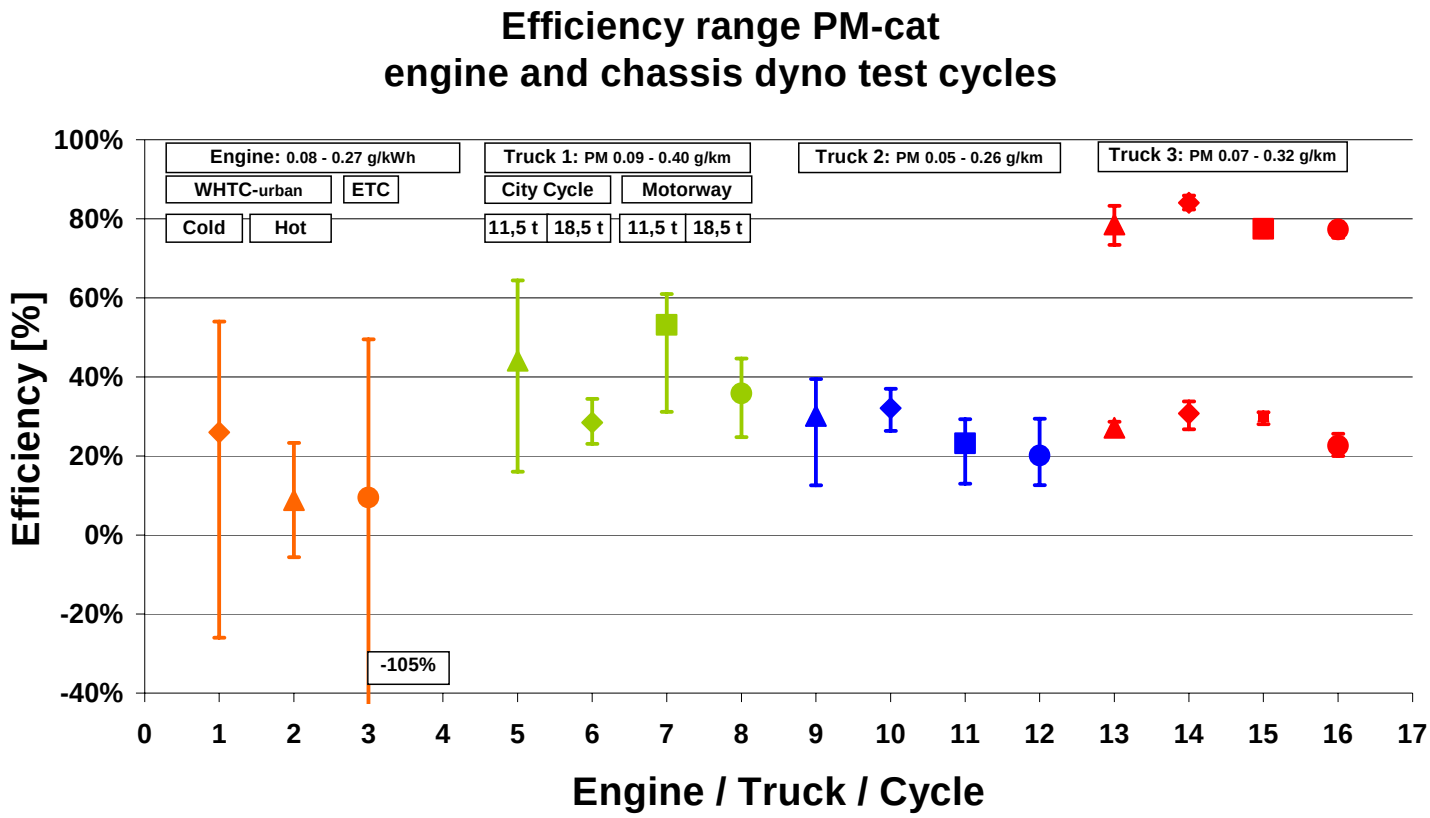
5. Test results temperatures pre PM-cat



- **Real world and laboratory PM-cat temperatures are similar**
- **Temperature pre PM-cat is adjusted to a real world level by adjustment of absorbed load**

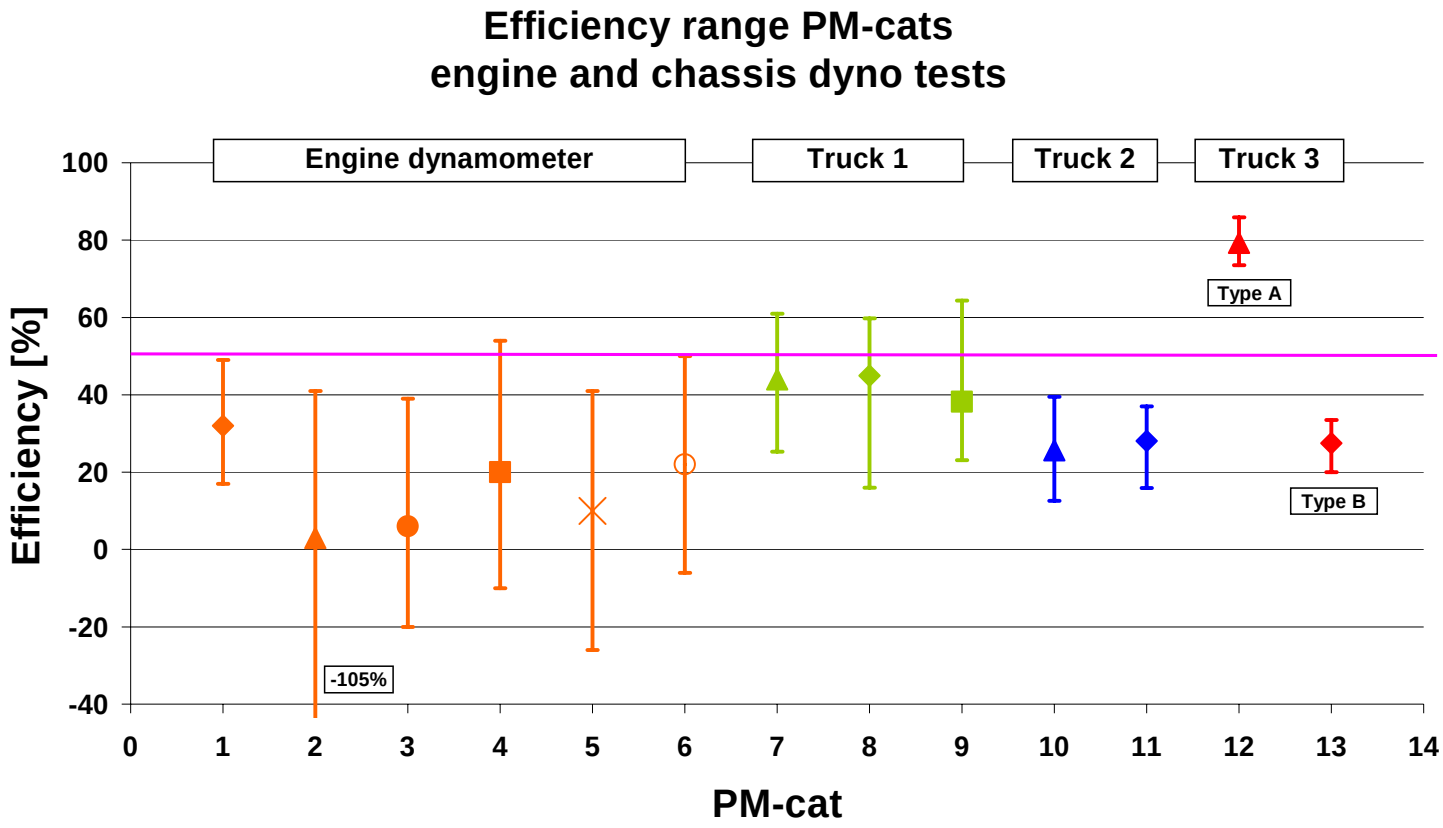
5. Test results PM-cat efficiencies per cycle

(minimum, average, maximum)



Some PM-cats have large variation in efficiency

5. Individual PM-cat efficiencies



- **Real world average efficiency of 13 PM-cats is 29.3 %.**
- **1 PM-cat has an average efficiency of more than 50%**

6. Discussion and conclusions

- Strong variation in efficiency between different PM-cat truck combinations
- Real world PM-cat efficiency lower than type approval:
  - Total average = 29 %
  - City driving = 29 %
  - Motorway driving = 29 %
- PM-cat efficiency is very dependent on the historic load pattern
  - Start type approval with realistic loaded PM-cat (>1 week real world)
  - real world load pre-conditioning (250 – 275 °C) should be a part of the type approval
- Separate test cycles for city and motorway driving should be considered for type approval

Thank you very much for your attention !

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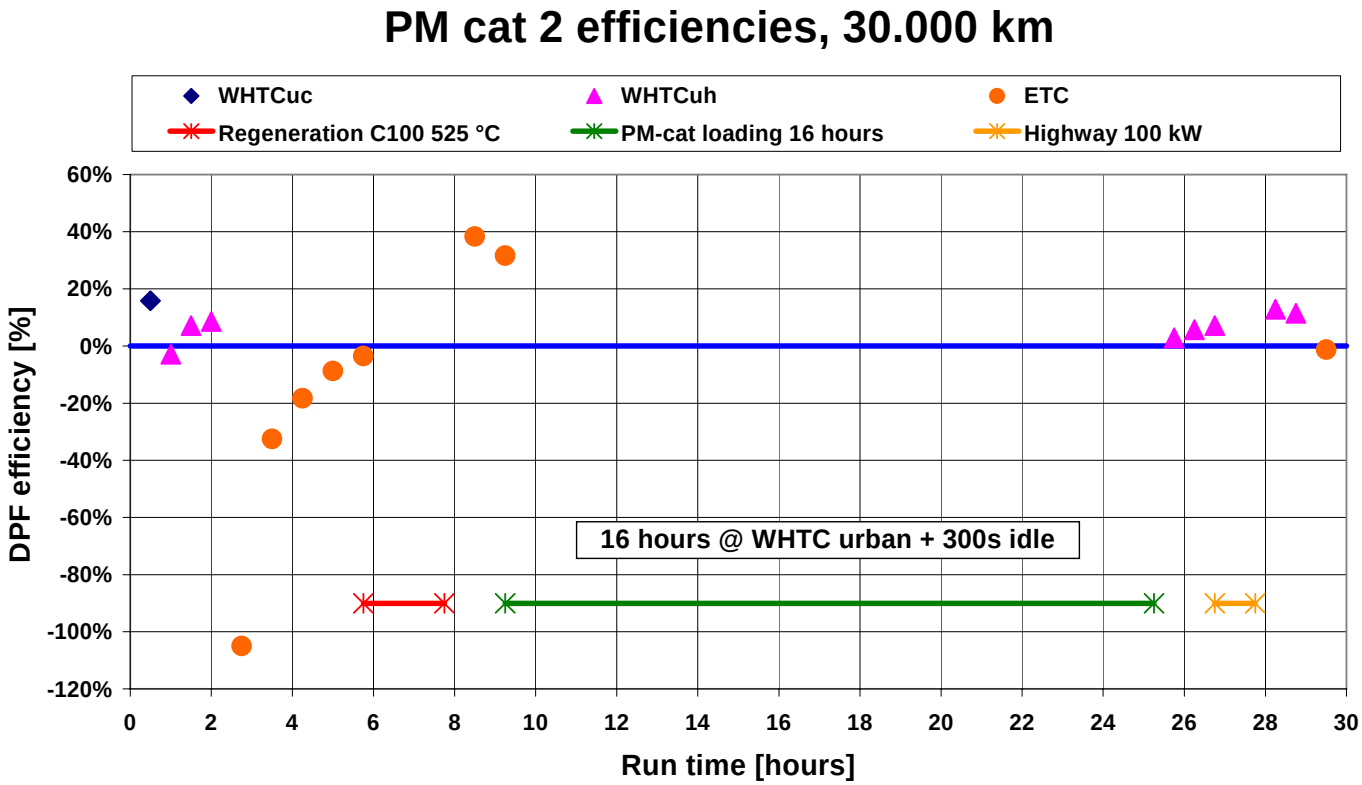
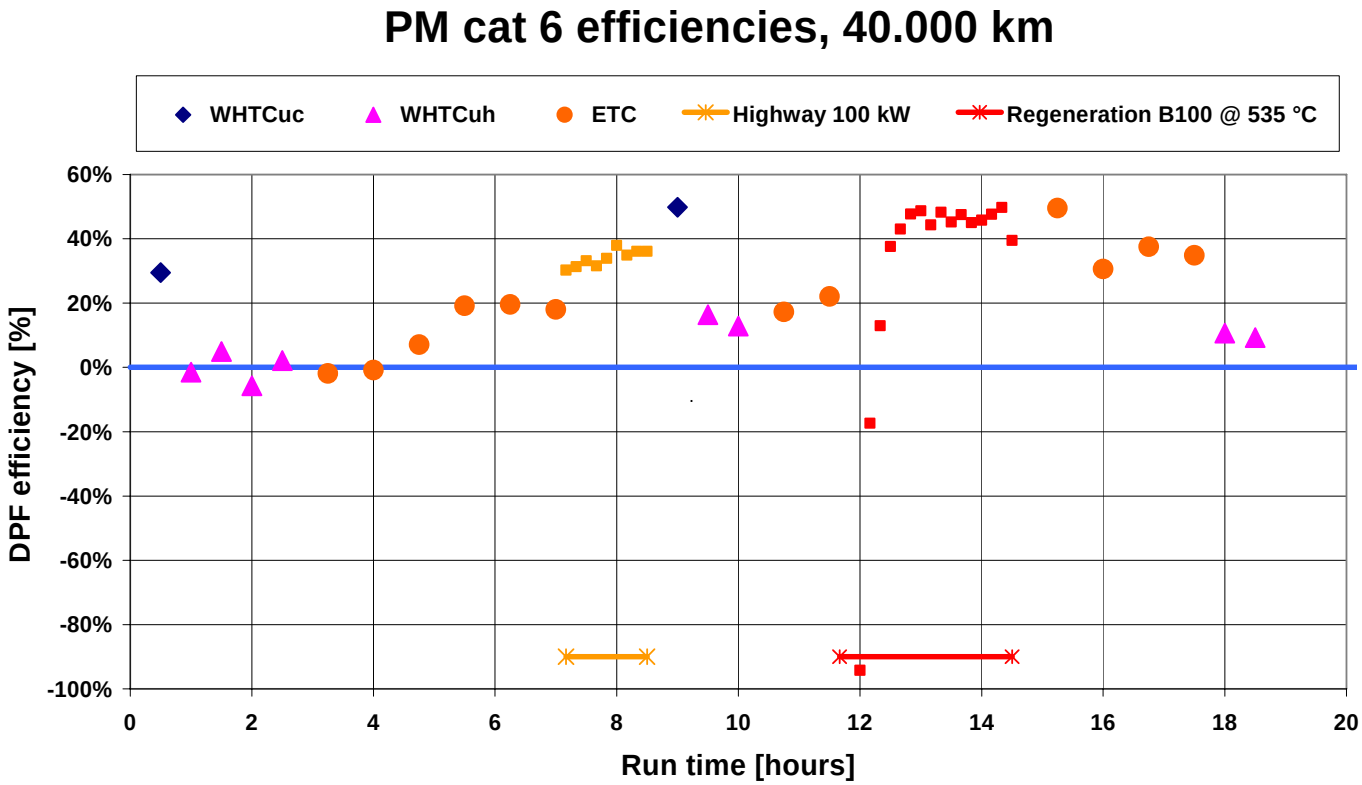
5. Results PM-cat 2 engine dyno (33.000 km/year)



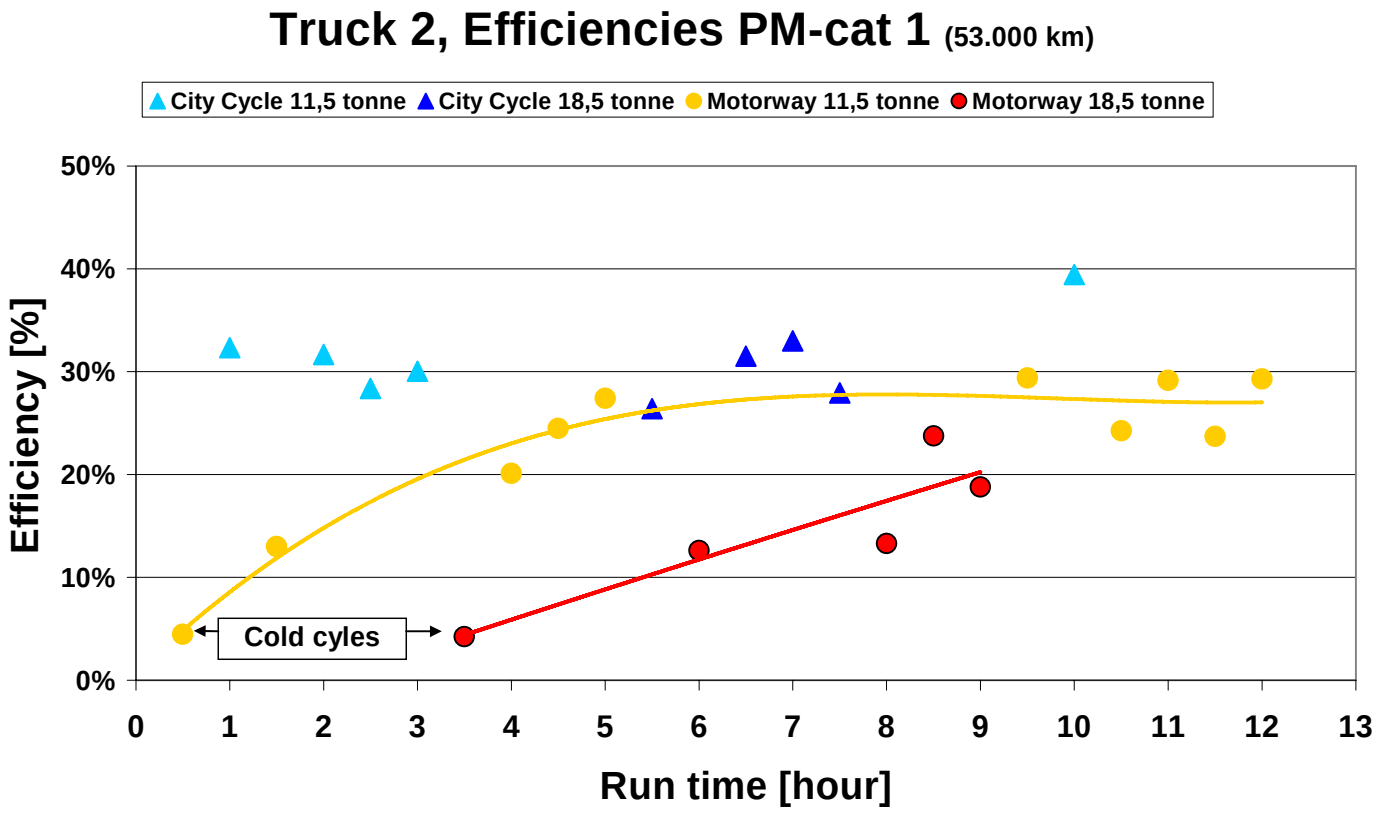
- PM-cat 2 has negative efficiencies and probably is loaded with PM (history)
- Stored PM releases during ETC-tests (PM-cat efficiency -107% - -3%)
- Extreme regeneration (2 hours @ 500 °C) removes stored PM, PM-cat efficiency is 40 and 32%
- 16 hours WHTC-urban + idle + 1 hour motorway results in an inactive PM-cat (eff. -1 - +13%)

5. Results PM-cat 6 engine dyno (29.000 km/year)



- First tests PM-cat efficiency is 0% and increases to 20% at higher loads (history)
- Steady state testing: PM-cat efficiency is 35 - 50%
- PM-cat efficiency in WHTC-urban cycle is - 6 – 5 – 16%
- After heavy regeneration PM-cat efficiency in ETC-test is 31 – 50%.

5. Results PM-cat 1 chassis dyno Truck 2, 45.000 km/yr



- **PM-cat history determines efficiency**
- **After a period of city use, the PM-cat efficiency on the motorway is poor**